U. S. DEPARTMENT OF AGRICULTURE,

OFFICE OF EXPERIMENT STATIONS,

A. C. TRUE, DIRECTOR.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1903.

BY

F. D. GARDNER,

Special Agent in Charge.

[Reprint from Annual Report of the Office of Experiment Stations for the year ended June 30, 1903.]

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ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1903.

By Frank D. Gardner, *Special Agent in Charge.*

INTRODUCTION.

The following pages give, in general terms, the progress of the work of the Porto Rico Agricultural Experiment Station for the year ended June 30, 1903. The appropriation made by the United States Congress for the year was $12,000. For the year ending June 30, 1904, however, this amount has been increased to $15,000, and now equals the sum which is appropriated annually to the experiment station in each of the States and Territories. The insular legislature also made an appropriation of $2,700 for the past year, to be used as follows: Drainage, $800; fencing, $500; tobacco investigations, $500; coffee investigations, $500; irrigation, $300; and painting, $100.

As stated in the last report, the station did not secure possession of its new location until the last week in June, 1902. Considerable of the work of repairing was, therefore, done during the present year and paid for out of funds from the same year. The setting aside of a considerable area of Government land in the northeast part of the island for a forest reserve, as recommended in our last report, has been effected through the proclamation of the President, dated January 17, 1903, and is known as the Luquillo Forest Reserve. It has been placed under the care of the Bureau of Forestry of this Department, and is thus the first forest reserve to fall under the administration of this Department.

Mr. C. R. Newton, clerk and stenographer to the station, resigned January 1 to accept a more responsible position as official stenographer to the supreme court of Porto Rico at San Juan. His place has been filled by Mr. E. C. Howe. Mr. P. A. English, farm foreman, resigned in February to take a place in the Treasury Department, and his place has been temporarily supplied by Mr. E. G. Bowersox. An examination has been held for the position of farm superintendent and it is probable that an appointment will be made to said position in a short time.

Negotiations have been underway for some time in reference to the employment of a horticulturist, but thus far no one has been appointed. The horticultural work has been pushed vigorously, however, by Mr. O. W. Barrett, but to the necessary neglect of his special investigations in botany and entomology.

The station is now well and permanently located, and a large number of important investigations are under way, as may be seen from the list of experiments on a following page. With the appointment of two more good men to take charge of horticulture and animal industry, respectively, the organization of the station will be very satisfactory and the field of investigations well covered.

IMPROVEMENTS AND EQUIPMENT.

The improvements have consisted chiefly in the repair and painting of buildings, building of fences, and repair and cleaning of roads and ditches. A barbed-wire fence of 3 new wires and posts of native wood at intervals of 15 feet has been built around the tract known as the "Ochenta;" the length of the fence is about 2,600 meters, or a little more than 1.5 miles. Forty rods of woven-wire highway fence have been erected along the highway leading from the city to the station farm. As a result of the appropriation made by the insular legislature for fencing, 550 rods more of the woven-wire fencing has been purchased and, at the present writing, is being erected.

The stable and wagon shed, which was brought from Rio Piedras, has been erected on the site of the old stable which has been torn down.

A plant house 60 by 80 feet in area has been constructed of poles, wire, and tent cloth, such as is used for tobacco shade. The uprights of native wood were cut from the farm, as were also the bamboo stringers, thus making the cost of the structure small. The most serious objection to the framework has been that the nodes on the bamboo have worn holes through the canvas. The nodes project very little, but they are so hard and cutting that it is recommended that they be carefully smoothed off wherever they come in contact with the canvas.

The additions to the equipment consist principally of small implements, such as hoes, spades, shovels, etc., together with a new set of work harness, a drainage level, and a new typewriter and bookcases for the office.

DRAINAGE.

Approximately 900 feet of underdrainage of bamboo has been put down in the experimental field and, up to date, has given excellent results. The nodes were cut out of the poles, thus securing hollow cylinders about a foot in length and from 2 to 4 inches internal diameter. These were sorted so as to place the larger ones at the mouth of the drain and the next smaller ones were gradually used as the head of the drain was approached. They were placed at an average depth of about 3 feet and were at once covered. They work quite as satisfactory as tile drain, but, of course, they can not be expected to last for a great length of time. In connection with the appropriation made

by the insular legislature for drainage the coming year, it may be said that negotiations thus far indicate that it will be more economical to purchase a small-sized tile machine and manufacture the tiles on the ground.

CLEARING AND PREPARATION OF LAND.

During the year two fields have been cleared of a considerable growth of brush, weeds, and grass, and plowed. The first, consisting of about 15 acres, was prepared during October and November, 1902, and was planted to general crops, such as rice, corn, beans, cowpeas, alfalfa, and kafir corn. These crops were planted chiefly as a preliminary preparation of the land for future experimental purposes. Owing to the lateness of planting, the severe attack of many insects, and the prolonged drought which prevailed from January 1 to May 15, these crops gave very poor results. After they were harvested the land was laid out into permanent plats, each 20 by 50 meters, or one-tenth of an hectare in area. Between the ends of plats was left roadways 5 meters in width for the purpose of turning rows and passage with wagons, etc., and along the sides was left a space 1 meter in width. A number of these plats have been planted to permanent crops, while others have been subdivided and used for annual crops, fertilizer tests, etc.

The second field, more recently cleared and plowed, contains about 25 acres, and is to be used for a general fruit orchard. A portion of this was planted to general crops in May, as soon as the rains began, but the results have been similar to those in the other field and indicate that very little may be expected from the first crops planted on land that has for many years been allowed to go to weeds and brush. The difficulty on such land is largely due to insects, especially the larval stage of various kinds, which seem to be abnormally abundant. With clean cultivation a great many of them disappear in a few months.

TRAVEL.

During the year the special agent in charge made a trip to Washington to prepare his last annual report and consult with the Director of the Office of Experiment Stations in regard to the general policies of the station. He also made one trip to San Juan, in February, to secure the introduction of an appropriation bill before the local legislature, which was then in session. Two trips were made during the year to the "La Carmelita," where the coffee experiments are being conducted, and one trip to Lajas, in company with Mr. Barrett and Professor Earle, to study the pineapple industry at that place. In addition to the above the station botanist and entomologist made a trip to Venezuela and Trinidad to study the cacao industry and collect

seeds of various economic plants for the station. He also made two trips in company with Prof. F. S. Earle, one to La Carmelita and one to Maricao, to study various plant diseases, as well as various short excursions for the purpose of collecting specimens.

SCOPE OF INVESTIGATIONS.

Tropical horticulture along a number of lines has appealed to us as being a very important, if not the most important, branch of investigation that the station could undertake. On account of the long time required for such work to give results, it was decided that it should be commenced at the earliest date. As previously stated, no horticulturist has thus far been secured, and Mr. Barrett, botanist and entomologist for the station, has been designated to look after the work, with the result that, since its inauguration, it has occupied nearly all of his time. The entomological and botanical investigations have, therefore, been necessarily neglected, although the demand for them, especially the entomological, has been as urgent as ever. In several instances insects have completely devoured a considerable area of field corn and cowpeas, as well as small plats of sweet corn, string beans, and other tender vegetables. Plant diseases of a fungus or bacterial character have been responsible for the total failure of several attempts to grow tomatoes, egg plants, and Irish potatoes. Scale insects of various kinds are prevalent on most of the young citrus orchards in various parts of the island.

The following experiments are now in progress:

Experiments at Porto Rico Experiment Station.

Experiment No.	Kind of plant.	Nature of experiment.	Experiment No.	Kind of plant.	Nature of experiment.
1	Bananas	Test of varieties.	19	Coffee	Effect of plant distances.
2	do	Test of fertilizers.			
3	Yautia	Test of varieties.	20	do	With and without shade.
4	do	Test of fertilizers.			
5	Cassava	Test of varieties.	21	do	Methods of pruning.
6	Yams	Do.	22	Citrus fruits	Tests of varieties.
7	Cacao	Do.	23	Orchard tests of miscellaneous tropical fruits.	
8	Leguminous crops	Comparative value of.			
9	Vegetables	Miscellaneous test of.			
10	Grasses	Tests of.	24	Coffee leaf miner.	Extermination of.
11	Cucumbers	Effect of fertilizers on.	25	Pineapples	Test of varieties.
12	Tomatoes	Do.	26	Bananas	Effect of plant distances.
13	Fiber plants	Test of kinds.			
14	Forestry experiments.		27	do	Methods of propagation.
15	Tobacco investigations.		28	Tea	Test of varieties.
			29	Rubber	Do.
16	Coffee	Treatment of old plantation.	30	Changa	Methods of exterminating.
17	do	Seedlings, effect of fertilizers.	31	Florists' bulbs	Test of varieties.
			32	Miscellaneous native crops.	Tests of.
18	do	Tests of varieties.			

Reports on the major part of the above list of experiments will be found in the reports of Mr. Barrett, under the heads of horticulture,

botany, and entomology, or of Mr. Van Leenhoff, under the head of coffee investigations.

The following experiments, on which brief report is made, have been under the immediate supervision of the writer, assisted by the farm foreman.

LEGUMINOUS CROPS.

On account of the impoverished and bad physical condition of much land in Porto Rico, considerable attention has been given to leguminous crops, with the hope of securing something that would serve in preventing, to a large degree, the severe washing of the soil, which now takes place on the steep lands and, at the same time, enrich the nitrogen content of the soil as well as improve its physical condition. As stated in the last annual report, alfalfa, common red clover, crimson clover, and alsike clover were tried at Rio Piedras, but that all were failures, except alfalfa, which was still living when the grounds were abandoned.

In November, 1902, about one acre was seeded to alfalfa on the experimental grounds at Mayaguez. A good stand was secured and the plants made a good growth. The dry season, which continued from January 1 to May 15, retarded the growth, but many of the plants bloomed. When the rainy season began, the plants made a new and vigorous growth for a short time, after which they nearly stopped growing and since which time they have barely managed to survive. No tubercles can be found on the roots, and it is believed this is the cause of the poor success. Arrangements have been made to inoculate some seed for a new plat, also to treat the soil of the present field. Two attempts have been made with each of three varieties of Turkestan alfalfa, with failure as a result.

Cowpeas have been tried a number of times, but always with failure. No tubercles have been found on their roots, and they are much troubled by a small leaf hopper (*Empoasca mali*) and a stalk borer.

Soja beans have done much better, but have not given large returns. The leaves, being covered with hairs, have been less subject to the attacks of the leaf hopper, but have been considerably damaged by a small spotted beetle which eats holes in them.

Beggar weed was tried, but only a few plants secured; these few have grown fairly well.

Velvet bean has done best of all. The vines when planted in drills one meter apart have completely covered the ground with a dense growth and given a good yield of beans.

The sword bean has also done well, but grows slower and for a much longer period than the velvet bean. Of all the legumes tried the velvet bean is the most promising and should prove a good plant for building up the nitrogen content of the soil.

GRASSES AND FORAGE PLANTS.

Two species of gramma and one of Bermuda have been tried for lawn purposes. The last named seems to be the most satisfactory. It spreads rapidly and is much finer and of better appearance than the gramma.

Teosinte, Johnson grass, and Bermuda grass have been sown on experimental plats and, although poor stands have been obtained, the indications are that either teosinte or Johnson grass will grow well and make good forage, although it is a question if either would equal the malojillo and Guinea grass that are now much used for that purpose.

Corn will grow and make fair yields on good land. The attempts made by the station to grow it on land that for years has been in weeds, grass, and brush has failed on account of the bud worms which work in the terminal bud, devouring the newly formed leaves. The native flint corn seems more resistant than yellow dent from the States, while sweet corn is so very tender that many attempts to grow it have resulted in absolute failure.

Kafir corn, sorghum, and broom corn have done fairly well and have proven more resistant than corn.

VEGETABLES FROM NORTHERN-GROWN SEED.

The following sorts have been planted:

Beets, beans, cabbage, cantaloupe, carrots, cucumbers, eggplant, lettuce, onions, potatoes, peas, radishes, sweet corn, squashes, tomatoes, spinach, watermelon.

Of most of these several varieties have been tried, while some have been repeated with various kinds of fertilizers, detailed reports of which will be given in coming publications.

Beets, cantaloupe, eggplant, beans, onions, potatoes, peas, sweet corn, spinach, tomatoes, and watermelons have either failed or done so poorly that nothing need be said about them.

Cabbages did well when care was taken to hand pick worms; without such care they are a failure.

Carrots made a moderate growth and gave roots of a fair quality.

Cucumbers were difficult to get through the early stage, but when well established have given fair yields.

Lettuce is also difficult to start on account of the heavy rains followed by scalding sun which destroys many very small and tender plants. When established it grows well, but frequently is more or less strong to the taste.

Radishes have grown without difficulty.

Tomatoes, potatoes, and eggplant have all been affected in a similar way by a bacterial or fungus disease which has proven fatal before the fruiting stage was reached.

FIG. 1.—PORTO RICO STATION—EXPERIMENTAL PINEAPPLE PLANTATION.

FIG. 2.—PORTO RICO STATION—EXPERIMENTAL BANANA PLANTATION.

FERTILIZERS.

Fertilizer tests have been in progress on a variety of crops, but thus far only a few of the crops have been harvested, so that results are yet undetermined.

Among the crops on which fertilizers have been tried may be mentioned yautias, bananas, coffee nursery beds, coffee trees, cucumbers, tomatoes, vegetables, and citrus nursery stock.

TEST OF VARIETIES OF PINEAPPLES.

There is no typical pineapple land on the station farm, so the plants have been set on a dry, gravelly ridge, which most nearly approached it. (Pl. XVIII, fig. 1.) The following varieties have been planted: Seven hundred plants of Cabezona, 150 plants of Pan de Azucar, 150 plants of Caraquena, 200 plants of Red Spanish, 200 plants of Smooth Cayenne, 50 plants of Egyptian Queen.

The first three varieties are common on the island and were secured at Lajas, which is the most noted pineapple district that we have. The remaining three were secured from Reasoner Brothers, Florida, through the courtesy of Prof. P. H. Rolfs, of the Bureau of Plant Industry, United States Department of Agriculture.

COTTON.

No systematic experiments have been undertaken with cotton, for the reason that considerable experimenting has been undertaken by persons who have recently organized the Walker Industrial Cotton Company. Their experiments extended to all parts of the island and to planting of different sorts every month through the year. They report about 8,000 acres planted during the present season, of which a large percentage promised a good crop. They recommend the Sea Island variety as best for planting and the month of May as a preferable time. The following extract is from the January, 1904, Crop Reporter of the United States Department of Agriculture:

> The London Times of December 21 quotes Mr. A. A. Paton, vice-chairman of the British Cotton Growing Association, as saying that he has sold, through Messrs. F. Zerega & Co., 13 bales of Porto Rico cotton at 14½d. (29 cents) per pound, and 33 bales more were to be delivered in Liverpool the same week. The first lot was sold in small parcels, so that cotton spinners might test its rare qualities. It was expected that from 1,000 to 1,200 bales in all would be shipped this season and that the prices realized would be such as to stimulate cotton growing throughout the West Indies. Messrs. F. Zerega & Co. presented the association above named with all the seed obtained from the cotton sold and it is to be distributed among the West India Islands. Mr. Paton is said to regard this Porto Rico cotton as the finest ever imported into Liverpool. A sample of it was submitted to an experienced broker who did not know its origin and was classified by him as good Sea Island.

METEOROLOGICAL OBSERVATIONS.

As stated in the last report, the meteorological instruments of the United States Weather Bureau, which were in the care of the voluntary observer at Mayaguez, were transferred to the station. The record is being continued and weekly and monthly reports sent to the central office in San Juan. A set of instruments has also been placed at the "La Carmelita," where the coffee experiments are being conducted, also an extra rain gauge, which is placed at the extreme upper end of the estate, at a considerably greater elevation than the first, for the purpose of ascertaining the effect of elevation on rainfall.

The following table gives the monthly rainfall at each of four places since the establishment of the United States Weather Bureau in the West Indies. These include the latest available data, and, being at the east and west ends of the island, as well as at the north and south sides, they show the extreme variation in rainfall to which the island is subject.

Rainfall (inches) in Porto Rico, as recorded by the United States Weather Bureau, January, 1899, to August, 1903.

Locality.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Hacienda Perla:													
1899	7.19	3.98	6.51	18.78	6.72	11.47	10.55	9.92	15.43	16.53	28.13	4.92	140.06
1900	12.05	3.67	4.43	23.34	18.70	18.55	11.04	11.95	15.30	15.83	8.36	8.70	151.92
1901	6.07	1.85	11.03	7.05	16.26	25.34	33.58	8.19	16.10	14.16	16.43	11.67	167.73
1902	13.99	.24	7.25	9.94	19.83	32.92	10.08	8.13	10.06	6.06	13.03	9.64	141.17
1903	4.37	2.44	3.88	7.55	10.28	7.40	14.40	10.61	.....	.....	.....	.....	.....
Mean	8.73	2.43	6.62	13.33	14.35	19.13	15.93	9.76	14.22	13.14	16.48	8.73	150.22
San Juan:													
1899	2.92	.80	2.29	6.09	2.59	7.23	7.53	10.38	13.66	10.21	11.81	2.10	77.61
1900	3.93	2.13	1.57	5.92	3.83	7.53	6.33	7.00	3.05	8.11	4.50	2.39	56.29
1901	4.36	.50	4.60	.66	4.84	7.05	10.98	8.59	7.39	8.30	9.55	8.43	85.25
1902	12.45	.09	4.08	6.09	13.97	12.22	4.61	4.66	4.85	3.13	5.65	7.16	78.96
1903	2.09	1.44	4.26	3.07	4.54	2.18	7.13	8.41	.....	.....	.....	.....	.....
Mean	5.15	.99	3.36	4.36	5.95	7.24	7.31	7.80	7.23	7.43	7.87	5.02	74.52
Mayaguez:													
1899	.....	.....	.....	.....	.....	.....	14.41	19.02	.....	8.73	3.52	1.04	.....
1900	1.49	1.06	1.21	5.44	6.14	14.03	13.11	14.02	7.44	12.47	2.99	4.20	83.57
1901	2.19	.58	5.72	.58	11.87	10.44	17.06	9.86	13.00	11.27	12.84	2.08	97.49
1902	4.67	.39	.13	10.85	16.56	8.33	7.62	5.80	7.60	5.82	9.14	4.48	81.39
1903	2.13	.33	2.19	1.74	11.58	12.42	10.86	7.89	7.77	.....	.....	.....	.....
Mean	2.62	.59	2.31	4.65	11.53	11.30	12.61	11.31	8.95	9.57	7.12	2.95	87.48
Yauco:													
1899	.....	.....	.....	.....	.....	3.50	3.81	.....	.....	.....	3.72	.....	.....
1900	6.05	.28	.....	.91	1.70	18.50	5.61	2.96	2.75	5.86	3.25	2.74	.....
1901	3.04	1.50	3.16	.37	3.78	1.27	9.72	4.30	9.57	3.36	7.52	1.52	49.11
1902	3.14	.12	.65	7.97	10.59	15.45	.....	2.98	4.60	3.58	1.82	3.74	.....
1903	1.26	.33	3.80	3.67	5.04	1.09	3.11	4.22	.....	.....	.....	.....	.....
Mean	3.37	.55	2.53	3.23	5.27	7.96	5.56	3.61	5.64	4.26	4.07	2.66	49.11

ADMINISTRATIVE WORK.

As time goes on the administrative work of the station increases. The correspondence has increased about 40 per cent over that of the first year. The total number of letters written during the year has been something more than 1,000. The duties as disbursing officer, together with the keeping of separate accounts for the Federal and insular appropriations, require in the aggregate considerable time. The detailed administration of the general field work, together with superintending the labor and keeping in order the general appearance of the farm and buildings, fully occupies the time of the farm foreman or superintendent and allows him very little opportunity even to carry out the details of experiments. The labor problem is quite different from that in the States. Labor, to be effective, requires constant and careful supervision. Without such supervision it accomplishes very little. There are far more workmen than places for them, and the best of them are quite satisfactory, considering the price, if given sufficient supervision.

MISCELLANEOUS NOTES.

During May and June, 1903, the services of Prof. F. S. Earle, of the New York Botanical Gardens, were secured, to make a study of some of the most important pathological diseases which occur on the island. The results of his investigations are appended as a portion of this report.

About 300 bound volumes have been added to the library during the year and the unbound publications have been largely increased.

The mailing list now numbers approximately 1,000 names and is daily increasing.

At the present time the work of tobacco investigation for the coming year, under the appropriation made by the insular legislature, have been commenced and arrangements made to continue the same throughout the year.

PLANS FOR FUTURE INVESTIGATIONS.

Most of the work commenced during the year will necessarily continue for several years and is sufficient to fully occupy the time of the present station staff. It is desired, however, to secure two additions to the regular staff, i. e., a horticulturist and a live-stock specialist, and also to retain the services of the tobacco specialist, who has already begun preliminary investigations under the small appropriation made by the insular legislature, through the year. With these additions to the staff, considerable more important work might be undertaken.

TOBACCO INVESTIGATIONS.

The tobacco investigations as outlined for the year consist, first, of a survey of the tobacco conditions in all the principal tobacco-growing districts, and second, of some detailed experiments on a plantation near Aguas Buenas. (Pl. XIX, figs. 1 and 2.) It is planned to conduct experiments in the preparation of seed beds, comparison of plants from Porto Rican, Sumatra, Habana, and Connecticut-grown seed for the production of wrappers, comparison of growing wrappers with and without shade, methods of topping and priming, effect of fertilizers on yield and quality of fillers, experiments in manner of curing, and also of fermenting. In short, the crop will be carried through from the seed to the product ready for the manufacturer. The cooperation of the United States Department of Agriculture would have been of great assistance in this connection, but, unfortunately, the appropriation for tobacco investigations was so restricted that it could not be used in the island possessions.

POMOLOGY.

As above stated, the investigations now begun in plant industry will be continued for some time to come. Prominence will be given, however, to pomology, and especially to the citrus fruits. An order has already been placed for 28 varieties of budded trees of orange, grapefruit, and lemon to be planted in the experimental orchard. As will be seen under the head of horticulture, seedlings from a variety of stock are now in the nursery and will form the basis of an elaborate investigation in the propagation of citrus stock for Porto Rico. For example, budding material from the best native orange ("china") that can be found will be uniformly budded onto stock of each variety that we now have to determine the best stock to be used. A considerable number of seedlings from what is now supposed to be the best stock will also be budded with a large number of standard varieties of orange to determine which is best suited to Porto Rico. Other experiments in reference to the best fertilizers to be used for orange trees, together with methods of soil management and the pruning of the trees, will also be inaugurated.

ANIMAL INDUSTRY.

It is doubtful if any work along this line can be commenced during the present year, because of the lack of funds. There is scarcely a doubt, however, but that the insular legislature will make provision for this line of work when the matter is properly laid before it. It will require a good man to take charge of the work and a considerable outlay at the start for the purchase of animals and the installation. The most promising lines to begin with would be dairying, swine husbandry, and poultry. There is also a demand for the breeding of

FIG. 1.—PORTO RICO STATION—SHADE-GROWN TOBACCO NINETY DAYS AFTER PLANTING.

FIG. 2.—PORTO RICO STATION—SHADE-GROWN TOBACCO AFTER SEVERAL PRUNINGS.

FIG. 3.—PORTO RICO STATION—CASSAVA NINE MONTHS AFTER PLANTING.

FIG. 4.—PORTO RICO STATION—YAUTIA, EIGHT MONTHS AFTER PLANTING.

larger horses for road purposes, and especially for good-sized mules for work purposes. At present all the interior road freighting and the plowing of land is done by oxen. Dairying should be confined, first, to the development of a good local milk supply, and second, to the manufacture of butter and cheese for home consumption. It would not be wise to attempt to do more than develop the industry for home consumption, for it presents certain difficulties which are more easily overcome in a temperate climate.

Swine industry should be, first, the introduction of a suitable breed for the climate, and second, to ascertain what tropical crops are best suited for producing pork.

The poultry should be improved in size particularly and with reference to both meat and eggs.

SOIL INVESTIGATIONS.

The soil survey, which was begun last year and of which a map has been prepared, should be continued. To be successfully carried on this work would require the cooperation of the Bureau of Soils. Certain restrictions laid upon the appropriation for the Bureau now prevents its cooperation in this regard.

Soil improvement by the application of manures and growing of leguminous crops will be fully investigated at the station grounds.

The cooperation of the various bureaus of the Department with the experiment station is desired to the fullest possible extent, and a scheme for such cooperation along various lines will be suggested for approval of the Secretary.

The cordial financial support which has thus far been accorded the station by both the National Congress and the insular legislature, together with the interest manifested by the planters in requesting its publications, is very encouraging and bespeaks for the station a high degree of usefulness.

It is confidently believed that the people of Porto Rico will meet the demands of the experiment station by adequate appropriations with which to enlarge its usefulness from year to year.

REPORT OF O. W. BARRETT, ENTOMOLOGIST AND BOTANIST.

During July attention was directed principally toward experiments with the changa (*Scapteriscus didactylus*) and with insecticide and fungicide tests in the vegetable plats. In August the experimental plats were harvested and a collection of the native crops in the vicinity was made and sent to the new station grounds at Mayaguez; some attention was also given to the herbarium and insect collection.

On account of the condition of the land at the new grounds and the time required to fit the soil for crops very little ecological work was attempted, the greater part of the time from September to December

being spent in studying the economic plants of the district and in laying out nurseries and propagating plats of same. The trials of native vegetables which were not completed in Rio Piedras were resumed. From January to July the work has been almost entirely of a horticultural nature. It has seemed best to give prominence to pomology, and a fairly complete collection of the native fruits, as well as many varieties of tropical and subtropical fruits from other countries, has been made; forage, fiber, and vegetable crops have been considered of secondary importance. Over 300 varieties of plants have been under investigation during the year.

RESULTS OF WORK.

The herbarium now contains about 325 species of economic plants; though but very little time could be allowed for botanizing, many interesting species have been secured in or near the station grounds.

Over 100 species of injurious insects have been studied. No attempt has been made to include the noneconomic species as yet.

A collection of the native woods has been commenced; about 100 cabinet specimens and a small number of "trunk sections" are already assembled.

As it was found impossible to prevent damage to the herbarium specimens from mold and insects when kept in ordinary cases, zinc-sheathed cases have been substituted with complete success.

Further study of the changa has resulted in no important results beyond those given in Bulletin No. 2.

Two trips were made in May, in company with Prof. F. S. Earle, of the New York Botanic Gardens, for the purpose of studying the fungus diseases of coffee and cacao. Three days were spent at the coffee substation.

In March a trip was made to Venezuela and Trinidad for the purpose of studying the methods of cacao culture in use in those countries and of securing seed of the principal varieties of the plant. Seven days were spent in Venezuela and five in Trinidad. Ninety-one varieties of seeds and plants were brought back, nearly all of which were new to Porto Rico. Although the culture of cacao, in Trinidad especially, is far better managed than it is in this island, it was concluded that our soils and climate compare very favorably with those of that island, and that with proper interest and attention the industry can be made very profitable here. In St. Vincent the manufacture of starch from arrowroot was witnessed. Two visits were made to the botanic gardens, St. George, Grenada, and a call was paid to the botanic station, Scarborough, Tobago.

In April a cheese-cloth tent 60 by 80 feet was erected after the style of the ordinary tobacco-shade tent. It was intended for use as a propagating shed, but as the texture of the cloth has proved too light to withstand the heavy rainfall and strong winds and too open-meshed to

afford sufficient shade, it has been on the whole a failure. Moreover, the atmosphere within being slightly more humid and warmer, conduces to fungus diseases among the seedlings. Previous to this several small palm-leaf sheds were used successfully.

PLANT COLLECTIONS.

The following collections of economic plants have been assembled:

BANANA PLAT.

About 3 acres of wind-sheltered hillside having a western exposure were set aside for the collection of bananas and plantains. This plat is intended for a variety test, a source for stock distribution of the more valuable kinds, and as an experiment in methods of planting, cultivation, and fertilizing (Pl. XVIII, fig. 2). In regard to the methods of planting, it has been found that the "ñame" (short portion of stem base with corm-like rootstock) was preferable for planting in dry soil; that the "tallo" (3-foot section of stem with root) gave best results in wet soil, and that the "pichón" (2–3-foot sucker or offshoot from stem base) was the most convenient for general purposes. The number of offshoots produced by each of these methods was nearly the same after eight months. Contrary to the popular belief it was indicated that drying the roots in the sun for several days previous to planting was injurious to the vitality of the plant and considerably retarded its sprouting. It is possible, however, that sun-baking may be more or less effective in preventing decay of the root when planted in wet soil. Very few of the "pichones" failed to start into growth within one month after setting, but about 5 per cent of the roots planted by the other methods rotted. Liberal quantities of wood ashes, phosphate rock, nitrate of soda, rotted coffee pulp, and stable manure were used without apparent effect. The plants which have made the best growth thus far are those growing in a heavy red clay which apparently contains very little humus though much moisture.

An experiment to determine the effect of allowing few and many offshoots from the parent plant to remain is in progress; three years will be required to terminate this experiment.

Although but five varieties of this most important fruit are commonly offered for sale in the markets of the island, an unexpectedly large number of the following native varieties has been procured from various parts of the island:

Enano.
Enano Doble.
Chamaluco.
Chamaluco Pato.
Guarán, or Gigante.
Guarán Doble.
Morado, or Colorado.
Morado Doble.
Colorado Blanco.
Rosa, or Dátyl.
Dominico.
Manzano.
Prieto.
Inglés.
Congo.
Congo Morado.
Plátano Hartón.
Plátano Trescientos.
Plátano Enano.
Plátano Cuarenteno.
Plátano Morado.
Guayabo.
Cenizo.

The following varieties were received from the Jamaica Botanic Gardens in January. It is probable that there are four to six reduplications of the native varieties under these names:

Martaban.
Pisang Sereh.
Pisang Almeido.
Pisang Kelat.
Pisang Rajah.
Pisang Soosoo.
Pisang Ambon.
Pisang Mass.
Pisang Râm-Kela.
Pisang Kudjo Hudang.
Pisang Palembang.
Red.
China.
Martabanica.
Champa.
Cinerea.
Guindy.
Lady's finger.
Lady's finger (Pashorgar).
Discolor.
Rubra.
Apple.

YAUTIA COLLECTION.

The collection of Yautia (*Xanthosoma* spp.) which was begun in Rio Piedras has been more than doubled, and it is believed to now contain practically all the known varieties. (Pl. XIX, fig. 4). This most valuable root crop appears to be confined to Tropical America, though perhaps the oldest cultivated plant in the world. Experiments have been begun in methods of planting. With one "short season" variety nine kinds of fertilizers have been used; the plant does not readily respond to chemical fertlizers, but stable manure has given very good results.

The collections consists at present of the following 25 varieties:

Rollisa, or Isleña.
Blanca.
Amarilla, or Huevo.
Punzera.
Prieta, or Morada.
Guayamera colorada.
Guayamera verde.
Cimarrona.
Palma.
Gris, or Amarilla de Mayagüez.
Martinica.
Isleña de Ponce.
Orqueta.
Rollisa Ancha.
Alocasia marshallii.
Alocasia batavensis.
1 Venzuelan variety.
2 Trinidad varieties.
6 Jamaica varieties.

The question of synonymy can not be fully worked out until the roots are harvested, but judging from the leaf and petiole characters, there is not a great amount of duplication among these names.

Though even the natives of Porto Rico commonly believe that the Yautia never flowers, a photograph of the flower of the "Martinica" variety was taken at the coffee substation (Pl. XX, fig. 3), and evidence was obtained that at least three other kinds have been seen in bloom.

The average market price (1½ to 2 cents per pound) of Yautia is about twice that of Taro, or "Malanga."

The very rare and interesting plant which is popularly known as "Yautia del Monte," and which had been considered an Amorphophallus, has been found to be *Dracontium asperum*, an Aroid from South America, not known to be native elsewhere in the West Indies. Two colonies of the plant occur at the station grounds, and specimens 8 feet high have been measured, the flower photographed, and the seed collected. The corm, sometimes 1 foot in diameter, is dug and eaten

FIG. 1.—PORTO RICO STATION—CITRUS NURSERY.

FIG. 2.—PORTO RICO STATION—COFFEE SEEDLINGS BEING TRANSFERRED TO PLANTATION.

FIG. 3.—PORTO RICO STATION—FLOWER OF XANTHOSOMA PERAGRINA, THE YAUTIA MARTINICA.

in times of scarcity of other roots; when boiled, it resembles a squash in color and flavor and seems to be free from rhaphides.

YAMS.

The following varieties have been assembled:

From Jamaica Department of Agriculture:
- Barbados Table, Lucia.
- Yampie, or Indian, St. Vincent.
- Negro.

Collected in Grenada, British West Indies:
- White Lisbon, St. Kitts.
- White, or Water, St. Lucia.

From Hawaii Experiment Station:
- Uhi.
- Hoi.

Native varieties:
- Gunda (*Dioscorea bulbifera*), Congo.
- Mapues Morado (*D. trifida*), Gulém.
- Guinéa, Agua.

Purchased: Chinese (*D. divaricata*).

Six species are represented in this collection. Most of the varieties, however, belong either to *Dioscorea aculeata* or *D. alata*.

An interesting yam bean, believed to be *Calopogonium cæruleum*, is under investigation. For unknown reasons it is very seldom cultivated, but is said to yield large roots of first-class quality.

An exchange of the yam varieties has been instituted between Hawaii and Porto Rico.

MISCELLANEOUS NATIVE CROPS.

Two varieties of the native papaw (*Carica papaya*) are being compared with a variety the seeds of which were received through Mr. G. N. Collins from Costa Rica.

The plat of "Maraca," or edible canna (*Canna edulis*), is proving less productive at Mayaguez than at Rio Piedras. The small plat at the latter place yielded roots at the rate of about 15 tons per acre. A large Hesperid butterfly (*Calpodes ethlius*) feeds upon the leaves, and a black fungus, the colonies of which occur in circular patches on the upper side of the leaf, is also injurious.

A plat of the rare root crop known as "Llerén" (*Calathea allouya*) is making a good growth. Though difficult of cultivation, this peculiar plant is highly prized by the natives of the interior, and is even sold in the streets of some of the large towns, the crisp, nut-like tubers ranking with peanuts in popularity.

The native "Malanga" (*Colocasia antiquorum esculenta*) is under comparison with the "Dasheen" (*Colocasia* sp. ?) of Trinidad. Our plant thus far appears superior to the imported one.

Arrowroot (*Maranta arundinacea*) is frequently found growing wild about the plantations; it responds readily to cultivation, but requires a fairly rich soil to produce a profitable yield.

The sword or horse bean (*Canavalia gladiata*) has given good results as a soiling crop.

Cowitch (*Mucuna pruriens*) produces a heavy growth of vine, but can not be utilized as a soiling crop on account of the poisonous bristles on the pods in place of the "velvet" of the velvet bean.

Two plats of sweet ginger (*Zingiber officinale*) made a good growth in sandy soil at Rio Piedras; the seed roots, however, remained some four months in the ground before sprouting. In clay loam at Mayaguez the crop has proved a failure.

A plat of Hedionda (*Cassia occidentalis*) did not respond to cultivation in the tests at Rio Piedras. The seeds of this plant are commonly mixed with coffee by the poorer classes, both for its reputed medicinal qualities and as an adulterant.

BULBS.

The following varieties of bulbs were received from a wholesale florist in Hoboken, N. J., for testing at Rio Piedras:

Lilium longiflorum, *L. longiflorum giganteum*, *L. longiflorum eximium*, *L. harrisii*, *Freesia refracta alba*, "White Roman" hyacinth, and "Paper White" narcissus.

Although the bulbs of the Easter lily (*L. harrisii*) were so badly affected with a fungus disease prevalent in Bermuda that about 25 per cent were destroyed upon arrival, fully 75 per cent of those planted reached a height of 12 to 18 inches and bore one or two (rarely three) good-sized flowers each. Practically all the plants showed traces of the fungus disease which has caused such ravages in the Bermuda fields during the last few years. Many plants, however, ripened seed, and about 85 per cent of the bulbs dug in August were apparently almost free from the disease. The average number of the "seed" bulbs produced on the stem above the old bulb was three to five; these appeared much more healthy than the old bulbs.

It is quite possible that the Bermuda or Easter lily can be successfully grown in the island, and at the present price (about $8 per thousand) the business should be fairly profitable. When planted in November a crop may be harvested in July or August, in time for the September trade.

According to our experiments, a light but rich sandy loam is preferred. Shade proved deleterious. The change did practically no damage to this crop. Neither of the two fertilized plats responded appreciably.

Of the Longiflorum varieties the Gigantium produced more flowers; both of these varieties were somewhat later in flowering than the Harrisii, and both showed serious traces of fungus disease.

Another case of lily bulbs (*L. harrisii* ?) was received from the same firm and planted at Mayaguez in September, with negative results.

The Roman hyacinths failed utterly; only about 1 per cent of the bulbs flowered. We suspect that both the "seed" and the phenological conditions were not good.

About 75 per cent of the narcissus bulbs flowered, but did not make a satisfactory growth thereafter and produced only a very small number of weak side bulbs.

Out of some 500 freesia bulbs planted not more than 25 per cent produced plants above 3 inches in height, and not one flower was produced.

The Barbados lily (*Hippeastrum equestre*), or "Mapola," is a weed in many places in Porto Rico, though it retails at 15 cents in the Northern market. Experiment proved that full-sized bulbs could be grown 4 inches apart in ordinary soil. Thus in a plat 11 feet square 1,000 salable bulbs could be grown with very little attention, and even at one-half cent apiece their cultivation should be highly remunerative, provided a market could be depended upon.

Three varieties of fancy-leaved caladiums were found growing wild in the station grounds at Rio Piedras. This plant is native to tropical America, and appears exceedingly hardy and very prolific of offsets. Small plants of the size which retails in the North at 10 to 15 cents were easily grown on the experimental grounds at Mayaguez. Cuttings of the parent bulb sprout readily, and in a moist, rich soil make a very rapid growth.

MISCELLANEOUS IMPORTED CROPS.

Seeds of the tree tomato (*Cyphomandra betacea*) were secured in Caracas, Venezuela, and the plants, though very sensitive to climatic influences, are growing slowly.

Plants of *Passiflora edulis*, from seed received from Jamaica Department of Agriculture, are doing well. Seed of a species of Passiflora were collected in Caracas; the seedlings are growing slowly.

Four kinds of tea—Japan, Anam, Amoy, and Dragon's Pool—received through the United States Department of Agriculture, have made a slow growth and many plants died in the dry season.

Nine varieties of Venezuelan beans have been tested.

CASSAVA.

A dry, gravelly patch of clayey soil underlaid with "Tosca" limestone was chosen for this collection. (Pl. XIX, fig. 3.) No fertilizer has been applied, but the plants have responded well to the clean cultivation given them.

The collection consists at present of the following 25 varieties:

From Jamaica Department of Agriculture:
- Rodney.
- Robby Hanson.
- Bunch of Keys.
- Black Bunch of Keys.
- Brown Stick.
- Yellow Belly.
- Fustic.
- White Top.
- Mass Jack.
- New Green.
- Auntie Gracie.
- Grey Stick.
- St. John.
- Garden Sweet.

Native varieties:
- Negrita.
- Coriana.
- Ceiba.
- Pata Paloma No. 1.
- Pata Paloma No. 2.
- Pata Paloma No. 3.
- Pana.
- Dulce.
- Miguela.
- Brava de Palo Verde.

From the Bureau of Plant Industry, U. S. Department of Agriculture:
- Florida Old Sweet.

FIBER PLANTS.

The four 2-inch seedlings of Manila hemp (*Musa textilis*) which were received in January from the Bureau of Plant Industry, United States Department of Agriculture, made a very slow growth at first, but are now beginning to throw out offshoots and one of the plants is 1 meter high.

The bulbils of the indigenous "maguey" (*Furcræa fœtida*) which were set in December, 1902, have reached a height of 18 inches, while suckers of the same species have attained nearly 3 feet.

The Cuban maguey (*F. cubensis*), known as "Cocuisa," has made a slower growth; the very spiny and comparatively short leaves, as well as the slow growth and poorer grade of fiber, render this plant unworthy of cultivation in this district.

Twelve small plants of the Bahama sisal (*Agave rigida sisalana*) were received in December from the Bureau of Plant Industry of the United States Department of Agriculture and have made a fair growth in a poor stony soil; they are now 1½ feet in height and are beginning to throw out the subterranean suckers.

Plants of the Indian madár (*Calotropis procera*), which grow wild in many parts of the island, have made a fairly good growth in stony soil.

The "Santa Maria," or *Sansevieria guineensis*, which also occurs wild in several districts, has been a failure owing to the too dry and poor soil. Much interest has been awakened in this fiber recently, but it is feared that it can not be grown in the poor soil which is so well suited to the maguey.

"Caillo" (*Urena sinuata*), a common wayside plant belonging to the Malvaceæ, makes a very rapid growth—about 2 meters in three months—and together with the following species is commonly used in making cheap cordage, thongs, etc.

Urena lobata, the wild jute of the fields, grows rapidly and can

readily be trained into a straight, few-branched, woody plant of 2 to 3 meters.

Plants of the true jute (*Corchorus capsularis*), grown from purchased seed, are making a fine growth and fruiting heavily.

A few seedlings of a rare shrub believed to be *Daphnopsis philippiana* were secured at the coffee substation and are now ready for permanent setting. Ropes made from the fiber of the bark of this plant can not be bitten off by horses or dogs on account of the abundance of rhaphides contained in the fiber cells.

Roots of the famous Arouma (*Ischnosiphon arouma*) were collected in the forest at Arima, Trinidad, but the attempt to cultivate the species has been a failure here as in Trinidad.

Young plants of the "Jipijapi" (*Carludovica* sp. ?) were obtained in Caracas, Venezuela; this species is said to produce the best grade of leaf for making "Panama" hats in Colombia and Venezuela. They are now growing in the cloth tent, but probably require greater humidity and more shade to attain perfect development.

Four old roots of *Carludovica palmata* have been received from the Bureau of Plant Industry, United States Department of Agriculture, one plant of which survives a "black-rot" disease.

Contrary to the popular belief experiments have shown that plants of the Porto Rico hat palm (*Inodes causiarum*) may be easily raised from seed; these seedlings, however, should be transplanted from the wet sand before they reach a height of 6 inches.

At the coffee substation the leaves of the "Palma de Sierra" (*Acrista monticola*) are made into cordage, hammocks, bottoms for cot beds, etc. If a market could be found for this coarse material a new industry would be opened; the supply is practically inexhaustible in the mountainous districts, especially in the Luquillo Forest Reserve. The young leaves of the royal palm (*Roystonea borinquena*) could be used similarly.

FOREST PLAT.

An experiment has been begun to determine whether a hill, barren of trees and composed of the common red clay over limestone, can be profitably afforested with native or introduced species of timber trees. About 4 acres have been set with seedlings, cuttings, and "volunteers" of 1 to 3 years of age; 100 square feet are allowed to each tree.

The present rank growth of grass and weeds serves as partial shade for the very young plants; as soon as required a space is cleared around each tree, the rubbish being used as a mulch during very dry weather.

A few species have been included, not so much for their timber values as for other economic purposes, as carob, logwood, kopok, bay rum, copal, etc.

The following species have been received from or collected at the coffee substation:

Cedro hembro (*Cedrela odorata*).
Cedro macho, or purple cedar.
Leche prieta (*Diphelis* ? sp.).
Mato.
Motilla (*Sloanea* sp.).
Yaya (*Oxandra* ? sp.).
Jaya.
Nuesmoscado (*Nectandra* sp.).
Canelo, or wild cinnamon.
Arroyo.
Arreján.
Sabina (*Magnolia splendens* ?).
Almendrón (*Prunus occidentalis*).
Guayabota (Eugenia?).
Aguacatillo.
Hueso blanco.
Corcho prieto.
Tabonuco (*Dacryodes hexandra*).

The following species have been received through the United States Department of Agriculture:

Sissoo (*Dahlbergia sissoo*).
Quebracho (*Schinopsis lorentzii*).
Grabrowskia glabra.
Brachychiton (*Sterculia diversifolia*).
Carob (*Ceratonia siliqua*).
Silk-cotton ("*Ceiba casearia*").

From Madagascar Experiment Station: Copal (*Trachylobium verrucosum*).

From purchased seeds:

Catalpa ovata.
Catalpa speciosa.
Albizzia julibrissin.
Gymnocladus canadensis.

From California Forestry Station:

Sydney Golden Wattle (*Cassia floribunda*).
Golden Wattle (*Acacia pycnantha*).
Black Wattle (*Acacia mollissima*).
Australian Blackwood (*Acacia melanoxylon*).
Oleander Wattle (*Acacia neriifolia*).
Red Gum (*Eucalyptus rostrata*).
Blue Gum (*Eucalyptus globulus*).
Manna Gum (*Eucalyptus viminalis*).
Karri (*Eucalyptus diversicolor*).
Sugar Gum (*Eucalyptus corynocalyx*).

From Trinidad Botanical Gardens: Logwood (*Hæmatoxylon campechianum*).

From Grenada Botanical Gardens: *Erythrina* sp.?

From Caracas, Venezuela: *Erythrina* sp.?

From San Juan, Porto Rico: Lebbek (*Albizzia lebbek*).

From vicinity of experiment station, Mayaguez:

Lechecillo (*Chrysophyllum monopyrenum*).
Cieneguillo (Eugenia?).
Hoja Menuda (*Myrcia*? sp.).
Capá Sabána (*Cordia* sp.?).
Roble (*Tecoma pentaphylla*).
Palo de Pollo.
Higuerillo (*Vitex divaricata*).
Cojoba (*Piptadenia peregrina*).
Moca (*Andira inermis*).
Jácana (*Lucuma multiflora*).
Guaraguao (*Guarea trichiliodes*).
Espino (*Zanthoxylum clava-herculis*).
Goano (*Ochroma logopus*).
Yagruma Macho (*Didymopanax morototoni*).
Malagueta (*Anamomis caryophyllata*).
Auzú (*Anamomis*? sp.).
Mameyuelo (*Ardisia*? sp.).
Indio.
Almendrón Cimarrón.
Aceituna (*Symplocos* sp.).
Jagua (*Genipa americana*).
Acacia.
Quitarán, or Abelluelo (*Colubrina ferruginosa*).
Guásima (*Guazuma guazuma*).
Guayabillo (Myrcia?).
Algarrobo (*Hymenæa courbaril*).
Bocare (*Erythrina micropteryx*).
Cafeillo (*Faramea odoratissima*).
Cañafistolo (*Cassia fistula*).
Santa Maria (*Thespesia populnea*).
Pomarosa (*Jambosa jambos*).

RUBBER PLAT.

In January 100 one-year-old seedlings of *Castilloa elastica* were received from the United States Department of Agriculture; 96 of these were brought through the long drought and have been trans-

planted into rows 12 feet apart in a 1-acre plat. In May some 500 seeds of *Castilloa* sp. were received through Mr. G. N. Collins from Nicoya, Costa Rica; these had been packed in moistened powdered charcoal and were germinating upon arrival; 100 of these rapidly growing seedlings will be transferred to the plat in September, 100 will be set in nursery rows, and the remainder will be held for distribution.

Fifteen seedlings of the West African silk rubber (*Funtumia elastica*) were obtained in September from seed received from the Trinidad Botanical Gardens; a few of these plants were lost during the dry season. The average height of the remaining specimens at nine months from seed is fully 1 meter; the unpruned form has a large, roundish head of bifurcating branches.

Seeds of Ceará rubber (*Manihot glaziovii*), received from Dr. John Gifford, have as yet failed to germinate.

Plants have been raised from cuttings of the native wild fig (*Ficus populnea*?) and will be set in the plat together with "volunteer" plants of same species procured in the vicinity.

CACAO PLAT.

At the "Moca" estate, one of the largest cacao walks in the hills near Spanish Town, Trinidad, a study was made of the varieties of cacao grown there, the propagation and cultural methods in use, and the fermentation and drying processes used in preparing the seeds for the market. Some 25 selected fruits, representing the 12 principal varieties, were obtained and brought back in almost perfect condition. The pods were sponged off en route with formalin solution as often as indications of decay were noticed. Seeds of the Alligator cacao (*Theobroma bicolor*) alone were lost.

The coolie labor system, which has been so well managed by the Trinidad Government, was also studied, but no form of it appears to be applicable in Porto Rico. Under this system the cacao trees are purchased from the Hindoo coolie, who is furnished seed, land, tools, and the right to build a hut and till a small tract for his own benefit. The trees may be sold by the coolie to the estate owner at any time after one year, but are usually cared for until bearing (three to five years) by the cooly, who must live constantly on the estate. The coolies are expected to do "piece" and day labor when required by the superintendent. On account of the coolie's propensity for saving his wages to his personal physical detriment, a large part of the daily wage is paid either in rations on the estate or through store checks.

No attempt toward artificial control of the ferments of the curing processes was noted. The popular impression is that no two lots of the "beans" can ever be treated the same way because of the differences between the seeds—all varieties being sweated together—as well as temperature and humidity differences. No white seeds were

observed. About 3 pounds of "beans" per tree is the average annual crop in Trinidad; that is, an acre containing 300 trees will produce about half a ton of cocoa, worth about $100. The life of a tree is indefinite, and a plantation should yield a practically continuous crop (8 to 13 annual pickings) for at least twenty-five years.

About half of the Trinidad cacao seeds were planted in large, shallow boxes of earth without fertilizer and the other half were planted in bamboo pots, one seed to each pot; each method was found to have some advantages over the other. The "damping off" was more easily controlled in the pots than in the boxes, but about 30 per cent of the seedlings were lost from this disease. In June about 350 selected seedlings were transferred into the plat without loss. The site selected for the experiment is a ravine, the sides of which were densely covered with second-growth shrubs and trees. This natural shade will be gradually cut out and replaced by "Bocare" (*Erythrina micropteryx*)—one shade tree to four cacao trees.

Two varieties of the Porto Rico cacao—the common Colorado (probably identical with the Trinidad "Forastero") and the white-seeded variety having yellow pods—are also represented in the collection. The white-seeded cacao is considered more difficult to grow, but of superior quality.

The Trinidad varieties are the following:

Calabacillo, red
Forastero-Cundeamor.
Criollo, red.
Large, smooth yellow.
Forastero, Ceylon, brown.
Lapp Forastero.
Criollo-Forastero, red.
Criollo-Forastero, yellow.
Criollo-Calabacillo.
Forastero, 5-angled, large seed, small, thin pod, acute tip.
Forastero, low grade.

FRUIT NURSERIES.

Experiments in cutting propagation of various varieties of native fruits have been made. A roofed shed open to the air on all sides is indicated as the proper locus for further work in this line.

Species from Trinidad:

- Bilimbi (*Averrhoa bilimbi*).
- Kokam butter (*Garcinia indica*).
- Carap, or crab-nut (*Carapa guianensis*).
- Nutmeg (*Myristica moschata*).
- Cannon-ball tree (*Couroupita guianensis*).
- Madagascar tamarind or Voa-Vanga (*Vangueria edulis*).
- Apple calabash (*Parmentiera cereifera*).

From Venezuela:

- Sweet lemon (*Citrus medica lumia*), a tree bearing medicinal seeds.

From Curaçao:

- Small, sweet mango (*Mangifera indica*).

From Grenada:

- Tahiti apple (*Eugenia malaccensis*).
- Nutmeg (*Myristica moschata*).

From United States Department of Agriculture:

- Jujube (*Zizyphus* sp.).
- Five varieties figs (*Ficus carica*).
- Pistachio (*Pistacia vera*).
- Wild pistachio (*Pistacia mutica*).
- Anatto (*Bixa orellana*).
- Pond apple (*Anona glabra*).
- Cherimoyer (*Anona cherimolia*).
- Kai apple (*Doyvalis* [*Aberia*] *caffra*).
- Cashew apple (*Anacardium occidentale*), from Beira, Portuguese East Africa.
- Bengal fig (*Ficus oppositifolia*).
- Coca (*Erythroxylon coca*).
- Cola (*Cola acuminata*).

Species obtained in exchange:

- Cluster or Gúlar fig (*Ficus glomerata*).
- Java plum (*Eugenia* sp.?).
- Surinam cherry (*Eugenia mitcheli*).
- Amatungula (*Carrissa arduina*).
- Loquat (*Eriobotrya japonica*).
- French mulberry (*Morus alba*).
- Chinese cinnamon (*Cinnamomum cassia*).
- Camphor (*Cinnamomum camphora*).
- Cuban Ti-es (*Lucuma rivicoa angustifolia*).
- Mexican white sapote (*Cassimiroa edulis*).
- Chinese guava (*Psidium lucidum*).
- Guinea guava (*Psidium guineense*).
- Cabada guava (*Psidium guayava*).
- Cattley guava (*Psidium cattleyanum*).
- Sour guisaro guava (*Psidium guayava*).
- Calcutta apple guava (*Psidium pomiferum*).

Species collected in vicinity of station:

- Ciruelo, or Spanish plum (*Spondias purpurea*).
- Jobo de la India (*Spondias dulcis*).
- Pear guava (*Psidium guayava*).
- Apple guava, or guayabo (*Psidium guayava*).
- Cereso (*Malpighia glábra*).
- Ceresas (*Cordia nitida*).
- Grosello, or Tahiti gooseberry (*Cicca disticha*).
- Calambreña (*Coccolobis nivea*).
- Mango (*Mangifera indica*), 3 vars.
- Aguacate, or alligator pear (*Persea gratissima*), 2 vars.
- Soursop, or guanábana (*Anona muricata*).
- Custard apple, or corazon (*Anona reticulata*).
- Wild custard apple (*Anona montana*?).
- Cashew apple, or pajuil (*Anacardium occidentale*).
- Mamee apple, or mamey (*Mammea americana*).
- Marmalade fruit, or mamey sapote (*Lucuma mammosa*).
- Nuez, or candle nut (*Aleurites moluccana*).
- Ginep, or quenepa (*Melicocca bijuga*).
- Genipap, or jagua (*Genipa americana*).
- Sea grape, or uvero (*Coccolobis uvifera*).
- Cocoa plum, or jicaco (*Chrysobalanos icaco*).
- Star apple, or caimito (*Chrysophyllum cainito*).
- Guayabillo (Calyptranthes?).
- Sapodilla, or níspero (*Achras sapota*).
- Guerrero (*Eupatorium dalea*?).
- Betel-nut (*Areca catechu*).
- Sweet orange, or china (*Citrus aurantium sinensis*).
- Sour orange, or naranjo (*Citrus aurantium amara*).
- Bittersweet orange, or ingierta (*Citrus aurantium amara dulcis*).
- Rough lemon, or limón bobo (*Citrus medica genuina* + *C. medica limon*?).
- Lime, or limón agrio (*Citrus medica acida*).
- Sweet lemon, or lima (*Citrus medica lumia*).
- Sweet lime, or limón dulce (*Citrus medica limetta*).
- Caracas sweet lemon, or lima (*Citrus medica lumia*?).
- Citron, or cidra (*Citrus medica genuina*).
- "San Domingan" orange (*Citrus aurantium sinensis*).
- Bergamot orange (*Citrus aurantium bergamia*).
- Mandarin seedling orange (*Citrus nobilis*).
- Kumquat orange, (*Citrus japonica*), 2 varieties.
- Grapefruit, or toronja (*Citrus decumana*).
- Myrtle orange (*Citrus aurantium* var.).

The greater part of the above nursery stock, except the Citrus varieties, will be set in the 25-acre orchard, which is nearly ready for planting, during the months of September, October, and November (Pl. XX, fig. 1). The trees will be set in rows 25 feet apart and 15 to 25 feet apart in the row, depending on the variety.

There are now in the budding rows (three plants to the meter in rows 1 meter apart) the following: 1,250 limón bobo, 1,000 naranjo, 200 china, 100 ingierta. These stocks will be ready for budding during the next rainy season. An experiment to test the comparative values of the above 16 (and other) stocks for budding with certain standard sweet oranges and the native Mayaguez "china" is contemplated.

SEED AND PLANT DISTRIBUTION AND ACQUISITION.

Several hundred packages of garden seeds received from the United States Department of Agriculture have been distributed to the rural schools and to estate owners.

Native bulbs, seeds, and roots have been sent to Hawaii, Honduras, and to several firms in California and Florida.

Collections of the three principal varieties of Porto Rican pineapples have been sent to the botanic stations in Antigua, Dominica, and Jamaica.

The botanic stations in the British West Indies have very generously offered to supply gratis to the Porto Rico experiment station the varieties of economic plants which may be obtained at their station grounds, a list of desiderata has been sent to Sir Daniel Morris, director of the Imperial Department of Agriculture in the West Indies, and to Mr. J. H. Hart, director of the Trinidad Botanic Gardens, and packages of seeds are being received at frequent intervals from the several British stations.

The two most valuable additions to our economic collections thus far have been the collection of bananas (22 varieties), tanier or yautia (6 varieties), yams (5 varieties), and cassava (14 varieties), secured from the Jamaica Department of Agriculture, and the collection of miscellaneous economic plants received from the Bureau of Plant Industry of the United States Department of Agriculture.

Besides Great Britain the only foreign country donating seeds or plants was Madagascar.

INSECT PESTS.

Insecticide experiments were carried on in July and August at Rio Piedras with the cotton bollworm, leaf hoppers, aphids, and the changa.

At Mayaguez the first entomological work to demand attention was

the eradication of the white ants, which, due to the semiabandoned state of the place, had become thoroughly established in the outbuildings, fence posts, and all mango and "jobo" trees in the vicinity. Over seventy-five nests were destroyed within 100 yards of the office building. As the arsenic treatment proved too slow and uncertain, recourse was had to burning with kerosene. A few ounces of the oil usually sufficed in dry weather to effect the entire destruction of a nest and all the insects therein. In a few cases the individuals which had been outside the nest at the time of its destruction returned and formed a small nest near the site of the old one. As many as eight queens were discovered in one nest, though four was an unusual number. The number of workers in a large colony was estimated to be from 50,000 to 100,000. The species has been determined as *Eutermes morio* (?). The winged form migrates from April to July. Live wood is very seldom attacked.

A smaller species, having hyaline instead of sooty wings, swarms in vast numbers in April, but no nest has been located yet.

It is recommended that all fence posts be well tarred before setting. The "poma rosa" (*Eugenia* (*Jambosa*) *jambos*) is especially liable to the attacks of white ants. The following kinds of woods may be used for posts in a "live" fence: Algarrobo (*Hymenæa courbaril*), jobo (*Spondias lutea*), bocare (*Erythrina micropteryx*), almácigo (*Bursera simaruba*), guayabo (*Psidium guayaba*), and molinillo or havilla (*Hura crepitans*). Of course some of these species will not take root in dry soil, but with a little care an ant-proof fence may be had which is practically permanent. The sprouting branches should be lopped off two or three times a year.

The changa has done more or less damage in the vegetable beds and nurseries. Repeated applications of the poisoned bait, as recommended in Bulletin No. 2, have served, however, to keep this enemy in check. Traps made by sinking 5-gallon kerosene tins just below the surface of the soil and lightly covering the open tops of same with small sticks, grass, and earth proved utterly useless.

CUTWORMS.

Comparatively little damage has been done by these insects, though a species of Prodenia has been quite numerous and hand-picking of the larvæ had to be kept up for some weeks in the Central American rubber-seed beds. Larvæ of an undetermined species were sent in from the coffee substation and reported as doing considerable injury in the coffee-seed beds.

The cotton bollworm (*Heliothis armiger*) destroyed a field of corn in November and December. Dropping or spraying Paris green in water into the heart of the young plants resulted in killing great

numbers of the larvæ, but the moths continued in force till February. From 1 to 4 larvæ on the average inhabited each "spear." Several species of flies were attracted to the frass thrown up by these larvæ and some of the smaller species bred therein. When much diluted, kerosene emulsion, whale-oil soap, and creolin solution were also tried, but although effective in killing the larvæ, seriously injured the corn itself.

COFFEE INSECTS.

The coffee leaf miner (*Leucoptera* (*Cemiostoma*) *coffeella*) has been studied with the hope that some means might be discovered for successfully combating this most serious enemy of the coffee in Porto Rico; but as yet no parasites of this minute moth have been observed and in only one instance were the larvæ found dead in the galleries between the upper and lower surfaces of the leaf, and no insecticide has been found applicable. This pest is now evenly distributed over the whole island; 20 per cent to 40 per cent of the leaves on each tree are affected, and sometimes 6 or more larvæ are found in the same burrow.

An experiment has been begun at the station grounds in Mayaguez to determine the result of removing all affected leaves in a plat of badly infested trees. Data are kept showing the number of leaves removed, the cost of the required labor, the average cost per tree, the reduction of the percentage of infested leaves by each picking, and an estimate of the benefit realized subsequently in the plat. The pickings will be repeated as often as reinfection renders necessary.

The red scale (*Lecanium hemisphæricum*) has proved troublesome locally, but as soon as the number of scales becomes so great that the individuals are clustered together closely on the branch, a cream-colored fungus usually appears and annihilates the whole colony. The hyphæ of this interesting and important fungus (which is being studied by Prof. F. S. Earle, of the New York Botanical Gardens) rapidly spread over each scale, the young and adults alike, and extends radially to some millimeters distance beyond. Very few coccinellid larvæ have been observed among the scales.

A plant louse (Aphis?) is occasionally detrimental to the young coffee leaves, but it is usually kept in check by the larvæ of a fly (Syrphus?).

A scale (*Orthezia* sp.), parasitic on the roots of unhealthy coffee trees, was observed at the coffee substation.

A fulgorid bug, having the entire body and wings covered with a grayish-white powder and consequently often mistaken for a moth, is rather common, but seldom found in large colonies. It attacks the young branches.

INSECT ENEMIES OF CITRUS STOCK.

The red scale (*Lecanium hemisphæricum*) is probably the most common scale on the orange here; since it infests many other plants it is liable to appear in any orchard at any time. Two to four applications of kerosene emulsion are usually necessary to rid a badly infested tree of this pest. This scale is sometimes parasitized by a hymenopter, as well as by the common whitish fungus, which is proving to be of great importance.

The purple scale (*Mytilaspis citricola*) is very common in all parts of the island; it is parasitized by a "red-fruited" fungus (*Sphærostilbe coccophila*) and a black slow-growing fungus (*Myriangium duriæi*), which was first observed at Naguabo and which is fairly common at Mayaguez.

The chaff scale (*Chionaspis citri*) is common everywhere on orange and lime.

Aspidiotus aurantii is rare but apparently spreading.

Ceroplastes floridensis was noted only in an orchard near Naguabo.

Chrysomphalus aonidum is rarely met with as yet.

Dactylopius citri is not common.

Aspidiotus articulatus occurs commonly in the eastern and northern districts.

Generally speaking the orange growers in Porto Rico are not giving sufficient attention to the scale pests in their groves; the spraying is entrusted to native laborers, who are certain to leave more or less unsprayed surface on each tree. One of the most promising groves has been very seriously injured by allowing the pests to become thoroughly established. Moreover, the insecticides are not always carefully made, and worse still, perhaps, old and badly infested native seedling trees are frequently left standing in or near the new orchards to breed and distribute endless generations of scales to the nurseries and young trees. Thousands of acres in the north part of the island have been planted with oranges in the past two or three years, and though it is natural that in this hurry and optimistic excitement such dangers are overlooked by the average planter, the prospective injury from scale insects in these new orchards might be very greatly lessened by a more careful attention to their present requirements.

In some groves considerable damage is being caused by a small brown ant which bites the bark and feeds upon the gum which exudes from the wound. Small branches are frequently girdled, and the loss of sap and gum through the numerous open wounds in time weakens the young tree. When not too close to the trunk of the tree a nest may be destroyed by pouring into it a few spoonfuls of carbon bisulphid and then covering with a wet gunny sack, but young trees are sometimes killed by the use of too much of the liquid near the roots.

Kerosene emulsion poured into the openings of a nest just after a rain is also effective in killing or driving away the ants. Fresh air-slaked lime placed close about the base of the trunk will for a time hinder the processions. Cloth bandages tarred or wet with creolin, corrosive sublimate solution, or crude carbolic acid solution are of some temporary value only; the two latter should be applied over a plain bandage of cotton batting.

The larvæ of a weevil determined as *Exophthalmus spengleri* was found eating the bark from the taproots of orange stock in a nursery near Rio Piedras. The adult insect is common throughout the island not only on citrus stock, but on nearly all kinds of fruit trees. A handful of air-slaked lime at the foot of the tree deters the female from entering the ground to deposit her eggs at that point. Hand picking will probably be found necessary to keep this pest in check for the next few years.

During the dry season two species of Lamellicorn beetles seriously damage the foliage of citrus stock and bananas. A boy with a lantern and a pail containing a little kerosene and water can easily collect a large per cent of these insects in an orchard by visiting the trees in the early part of the evening; for large trees a sheet spread under the branches may be used by two or three boys to better advantage.

INSECT ENEMIES OF MISCELLANEOUS FRUIT TREES.

Diaspis pentagona has proved very destructive to peach trees in the east part of the island; this species also attacks mulberry and papaw. Although not difficult to control, the native makes no attempt to rid his dying papaws of this "piojo" (louse).

Aleurodicus minima injures the wild guava (*Psidium guayava*) in some localities.

Asterolecanium pustulans has appeared on the fig (*Ficus carica*) at the experiment station.

An undetermined scale (Vinsonia?) occurs on the rose apple (*Jambosa jambos*).

The Guanábano (*Anona muricata*) is everywhere affected with *Lecanium hemisphæricum;* and an aphid frequently joins its efforts to weaken the tree, and by its habit of attacking the flowers probably prevents the "setting" of many fruits.

A thrips and a Dactylopius have injured Pajuil seedlings (*Anacardium occidentale*) in our nurseries; a few of the plants were killed in spite of kerosene emulsion treatment.

An aphid appeared on the Castilloa plants, but was exterminated by a lace-wing fly (Chrysopa?).

The flower clusters of cacao (*Theobroma cacao*) are frequently attacked by a brownish aphid, and the punctured and weakened pedi-

cels and embryo fruits thus become very liable to the attacks of the pod-rot fungus.

Vinsonia stellifera occurs commonly on the cocoanut (*Cocos nucifera*). At Ponce many of these trees are dead or dying from attacks of *Aspidiotus destructor*. This scale is parasitized, however, to some extent by a Tineid moth, the larva of which forms a web over the scales on the worst-infested leaflets and gradually devours the entire colony, though not soon enough to save the life of the leaflet; attempts to rear this interesting insect have been unsuccessful thus far and but one imago was seen in situ.

MISCELLANEOUS INSECT ENEMIES.

A cricket (*Gryllodes muticus*) has proved a serious pest in the station's nurseries and seed beds, many valuable plants having been cut off just above the ground. In one case freshly cut leaves were found in the burrow of this insect, which had thus adopted one of the changa's (*Scapteriscus didactylus*) clever habits. A cricket, presumably this species, was reported as doing considerable damage in the coffee seed beds at the coffee substation.

A small fly (*Lonchæa chalybea*), previously known from Brazil, has caused much damage in the larval stage by boring into the terminal buds (rarely petioles) of cassava (*Manihot utilissima* and *M. palmata aipi*); hand picking is the only remedy since the openings to the burrows are closed by a granular, gummy secretion; the brittle terminal bud is broken off and dropped on the ground where the immediate "bleeding" and withering of the bud imprisons and kills the young maggots. Mature cassava plants are usually attacked by a small bug of the Tingitidæ (*Atheas nigricornis* ?); the under surface of the full-sized leaf is the only part attacked and, therefore, successful spraying is exceedingly difficult, especially since the insect is possessed of great vitality. A brownish mite also causes injury to the young cassava leaf; the epidermis of the under surface of the basal portion of the blade is the usual point of attack. *Lecanium hemisphæricum* and an undetermined white scale have been noted on stems of cassava.

Practically no insect enemy of the yautia (*Xanthosoma* sp.) has been observed yet; however, a black aphid was found on a plant purchased as *Alocasia marshallii*, but believed to be a Xanthosoma, and a mite was noted on the upper surface of the leaf blade of a plant bought for *Alocasia batavensis*, but which appears identical with the common yautia known as "Guayamera."

The malanga (*Colocasia antiquorum esculentum*) is occasionally attacked by an aphid which is usually parasitized by a whitish fungus and a hymenopter.

A scale (Dactylopius ?) attacks the "heads" of Guinea yams at

Mayaguez. One variety of yam brought from the botanic gardens at St. George, Grenada, was badly affected with *Aspidiotus hartii*.

The minute leaf hopper (*Empoasca mali*) has been the severest insect enemy of beans and cowpeas; spraying is almost useless. *Agallia tenella* and several Tettigoniids have also injured beans and other small crops.

A lepidopterous stem borer has destroyed many plants in the bean plats and has greatly hindered the growth of the horse beans.

The bean leaf beetle (*Cerotoma denticornis*) is common.

Plutella maculipennis was very abundant on cabbage at Rio Piedras; it was controlled by repeated applications of "slug shot" reinforced with paris green.

A flea beetle (*Systena basalis*), in company with a root fungus, has ruined a plat of Russian sunflower at the station.

Larvæ of a weevil (apparently Sphenophorus) were observed in sugar cane at Ponce.

Protoparce carolina occurs commonly on tomato and tobacco throughout the island; the larvæ are usually killed by a thrust of a knife made from a Maya (*Bromelia pinguin*) leaf.

The melon worm Pyralid (*Diaphania hyalinata*) has proved a severe pest throughout the year, both at Rio Piedras and Mayaguez, on squash, cucumber, and melon; while small the plants can be kept from serious injury by hand picking the young larvæ in the buds and new leaves, but when the plants are mature this becomes a laborious task.

PLANT PARASITES.

Several species of Loranthus are common on various fruit and timber trees; in the vicinity of Ponce many fine trees were noted killed or dying from the parasitism of a white-fruited Phoradendron. The calabash (*Crescentia cujete*) is very frequently attacked.

A dodder (*Cuscuta americana*?) was with difficulty eradicated from a plat of alfalfa in the trial grounds of the station at Mayaguez. This species occurs commonly on low shrubbery, especially along the sea shore.

Bromeliads and orchids are occasionally found on coffee; these do little or no damage to the host, though causing a shabby appearance. Lichens and liverworts, however, undoubtedly injure the leaves and bark of coffee by retaining excessive moisture, obstructing respiration, and furnishing a foothold for various fungi; since these plants thrive only in very humid situations, the "opening up" to more light and better air circulation will soon ameliorate the condition of the "mossiest" patch of trees.

The Guamá (*Inga laurina*) is very frequently affected with a peculiar disease of the peduncle. This organ becomes excessively branched and, each branchlet being distorted and abbreviated, the infertile mass

of pedicles assumes a more or less spherical shape, becomes a harbor for coccids, ants, cockroaches, etc., and is believed by many peons to give rise to a "rust" disease of coffee growing beneath such shade trees. Although coffee does frequently die under Guamá trees badly affected with the peduncle disease, no etiological connection has been established between the two effects. The peduncle disease appears to be of a physiological rather than of the "witches broom" (Exoascus) type.

The Guaba (*Inga vera*), which is usually preferred for coffee shade, appears to have no enemy other than the fungus mycelium which sometimes attacks the roots of coffee and coffee shade trees in small areas in old plantations. It is, however, much less prolific than its related species, the Guamá, producing but one light and irregular crop of more or less imperfect fruits, instead of two heavy regular (May and October) crops of seeds in an edible pulp.

FUNGUS DISEASES.

The following fungi have proved more or less injurious during the year:

Cladosporium citri, damaging sour stock in citrus nurseries.

An undetermined "spot" fungus appearing on the under side of citrus leaves and resembling "melanose;" this disease occurs commonly throughout central Mexico in the old orange groves.

A red-spored "damping off" disease of citrus nursery stock in seed beds.

Stilbum flavidum on coffee at the coffee substation; not common.

A root disease of coffee caused by the subterranean hyphæ of an undetermined fungus (Polyporus?). This disease spreads radially, killing the shade trees and nearly all plants in its course, but its progress is fortunately very slow. Ditching around the infected area is advised.

A red-spored fungus occurring in spots on the leaves of the Avocado pear causes some damage locally. Practically all of the Avocado pear trees in a district near Joyuda were reported to have died simultaneously. The cause was not determined.

Graphiola phœnicis is well established on the date palms of the island.

Cercospora sp. occurs on Hedionda (*Cassia occidentalis*).

Cercospora personata injures peanuts (*Arachis hypogæa*).

Cercosporium beticola is one of the four or more root rots of the bean.

Coleosporium ipomœæ appears in red-brown spots on sweet potato leaves, but it is parasitized by *Ramularia coleosporii*, which appears as a white dot in the center of the host colony.

A root rot of the potato (*Solanum tuberosum*) resembles in its effects the "black collar" form of *Rhizoctonia solani*. This fungus seems to preclude the growing of this crop in Porto Rico.

A blight on tomato, which has been under investigation for over a year and which may prove to be *Bacillus solanacearum*, has destroyed many plats in our experiments. Its action is apparently downward through the vascular bundles which enter the petiole. No amount of Bordeaux mixture has any appreciable effect.

REPORT OF J. W. VAN LEENHOFF, COFFEE SPECIALIST.

As stated in last year's report, a beginning was made in January, 1902, with the establishment of coffee seed and nursery beds, the object being the production of select plant material for experimental purposes and for free distribution among coffee planters with whom the station might wish to cooperate. (Pl. XXI.)

As the station had selected, but had not yet been able to secure possession of the desired lands for experimental purposes, these beds were constructed in the immediate neighborhood and on soil which afterwards proved to be very much impoverished. (Pl. XXII, fig. 1.)

Up to the present time, except in a very few instances, coffee planters obtain their seedlings only from plants grown from berries which for different reasons have fallen from the trees and gradually grown up on the same spot, forming in many instances, dense underbrush, making cultivation of parent trees impossible and exhausting the soil to a large extent. As all kinds of berries, from good and bad parent trees, ripe and unripe, sick and healthy, large and small, are to be found among fallen ones and a large percentage of them germinate, the seedlings for this reason alone do not offer a sufficient guaranty to produce healthy and desirable plant material. In fact, the constant use of such material may have produced a degeneration to which the present small crops per acre may be partly attributed. Once the seeds have germinated, they are permitted to grow under dense shade with hardly any light or ventilation, and consequently they become as a rule long, slender weaklings. The roots, grown in uncultivated soil and, because of the crowded condition of the plants, all intermingled, do not have the desirable form of a straight taproot and pyramidal distribution of side roots. Instead of this all kinds of bent forms, knots, and rottenness are general. Several thousands of such seedlings derived from different plantations were inspected, and in many instances not a single one was found with a well-formed root system.

After the germination and the full development of the first leaves in the seed beds, the young plants were transplanted into nursery beds constructed similarly to the seed beds. Before transplanting, 54 of the beds were treated with the following fertilizers: Nitrate of soda, muriate of potash, lime phosphate, bone meal, stable manure, and

Porto Rican bat guano, all applied alone and in different mixtures. The results of these different treatments were that all the beds treated with bat guano or with mixtures of same with other fertilizers gave splendid results, the plants growing twice as fast as those in the other beds. Other manures or fertilizers seemed to have very little or no effect. The bat guano was obtained from deposits in caves, of which a large number exist in the island of Porto Rico.

An analysis of same, as made by the Bureau of Chemistry, United States Department of Agriculture, is given below:

	Per cent.
Total phosphoric acid	12.93
Total potash	.96
Total nitrogen (nitrates, present) equivalent to	3.32
Ammonia	4.03
Moisture	13.86
Loss on ignition	52.33

In October and November all the plants, after they had been gradually uncovered, were standing in the full sunlight, and at the end of November were sufficiently accustomed to the sunlight to be transplanted to the field. Not having yet obtained control of the desired lands, it was decided to leave the plants a year longer in the beds, during which time they developed into fine-looking plants and are now being used for planting in the experimental fields or for supplying planters who are cooperating with the station, the stump-planting system being used.

IMPROVEMENT OF OLD COFFEE GROVE.

As already mentioned in a former report, 10 acres of old coffee lands were divided into 10 square plats of 1 acre each and numbered from 1 to 10. (Pl. XXIII, figs. 1–4.) The crop produced on these plats before any experiments were made was ascertained, with the following results:

Product of 10 acres of Porto Rican coffee in the barrio Anon, district of Ponce, Porto Rico, 1902.

Acre No.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Total.
Ripe berries:											
In liters	1,800	1,516½	2,520	2,659	369	597	378	278	545	523	11,185½
In pounds	2,477	1,973	3,415	3,752.5	500	852	529	383	701.5	711	15,295
Coffee ready for market, in pounds	545.5	459.5	763.5	805	113	181	114	84	163	158.5	3,387

The harvested berries were measured by almudas to a total of 559.25, for which the pickers were paid 7 cents per almuda, or a total of $39.15. This quantity produced 3,387 pounds of coffee ready for market, therefore—

1 pound berries about equals 0.22 pound ready for market.
1 almuda berries about equals 6 pounds ready for market.
1 liter berries about equals 0.30 pound ready for market.

The cost per 100 pounds of harvesting and marketing coffee was as follows:

Picking	$1.16
Pulping, hulling, and drying	.60
Transporting berries from field to factory	.10
Transporting to Ponce market	.25
Total per 100 pounds	2.11

After the harvesting of the old crop the whole of the 10 acres were carefully weeded and the coffee as well as the shade trees provisionally and roughly pruned, immediately after which operation acres numbered 1, 3, 4, and 8 were selected for making a beginning for the different improvement experiments. For this purpose each of them was divided into 4 square plats of one-quarter of an acre each, making a total of 16 plats, numbered from 1 to 16. The first 4 numbers being of the original acre No. 1, the second of acre No. 3, and so on.

The following operations were then undertaken:

Plat No. 1. Experiments were made with leguminous plants as fertilizer. All vegetation except coffee and shade removed. Coffee, distanced at practically 8 by 8 feet, by removing all trees at less distance. Cowpeas were planted and after they had come up very nicely were plowed under.

Experiment with plant distances.

	Spaced.	Coffee trees.			Spaced.	Coffee trees.	
		Removed.	Remaining.			Removed.	Remaining.
	Feet.				*Feet.*		
Plat No. 1	8 by 8	238	130	Plat No. 8	7 by 7	107	103
Plat No. 2	8 by 8	125	110	Plat No. 9	6 by 6	215	207
Plat No. 3	7 by 7	63	92	Plat No. 10	6 by 6	138	137
Plat No. 6	6 by 6	110	113	Plat No. 11	7 by 7	110	147

Making a total of 8 plats, or 2 acres, on which were removed 1,106 and remained 1,039 coffee trees. Plats 4, 5, 7, and 12 were left as check plats in their original state.

CUTTING COFFEE TREES TO STUMPS.

On plats Nos. 9 and 10 all existing coffee trees were cut to stumps about 6 inches high, and besides on plat No. 9 all shade trees were removed. Very soon the stump began producing new shoots, in most instances in large quantities. As soon as the shoots had attained a height of a few inches, all of them except two opposite ones were removed from each stump, and since that time the shoots have grown very rapidly, but quicker in No. 9 than in No. 10.

Besides the above-mentioned experiments, all the trees of the first 12 plats were thoroughly cleaned by rubbing with a rough cloth and afterwards painted with lime milk. The general appearance of the trees has improved greatly.

PORTO RICO STATION—LA ISOLINA, A COFFEE PLANTATION.

FIG. 1.—PORTO RICO STATION—COFFEE-SEED BEDS UNDER ARTIFICIAL SHADE.

FIG. 2.—PORTO RICO STATION—COFFEE CROP, 1901. LEAVES REMOVED IN 1900 TO COMBAT LEAF MINER.

FIG. 1.—PORTO RICO STATION—FOREMAN'S HOUSE AT THE COFFEE EXPERIMENTS.

FIG. 3.—PORTO RICO STATION—PREPARING PLANT HOLES FOR COFFEE.

FIG 2.—PORTO RICO STATION—FELLING THE VIRGIN FOREST.

FIG. 4.—PORTO RICO STATION—ORIGINAL CONDITION OF OLD COFFEE PLATS.

RENOVATING OF OLD COFFEE PLANTATION.

Plat No. 13. All coffee and shade removed; plowed, harrowed, and planted to soja beans.

Plat No. 14. All coffee removed, shade left.

Plat No. 15. All coffee and shade removed; plowed, harrowed, and planted to alfalfa.

Plat No. 16. All coffee and shade removed; plowed and harrowed and planted to cowpeas.

The soja beans, after coming up nicely, were damaged by heavy rains, but afterwards recuperated and are now doing fairly well.

The alfalfa was entirely destroyed by heavy rains after having come up nicely.

The cowpeas came up very nicely and grew luxuriantly, and were plowed under before the beans had entirely ripened. After some further preparation the plats will be set to new coffee trees from the nursery beds.

EXPERIMENTS WITH NEW COFFEE.

The object in view is to improve upon the present condition of coffee trees in Porto Rico. Generally speaking this may be done in two different ways—(1) improvements in the Porto Rican coffee and shade trees themselves, and (2) improvements in the Porto Rican coffee by cross breeding, budding, or replacing by foreign coffee and shade trees.

In order to make experiments along these lines possible, a part of the 25 acres of virgin forest mentioned in last annual report has been cleared and a road made through it. Two houses for the foreman and laborers have been built. An imaginary line running north and south through the center of the tract divides it in two parts. To the east of this line experiments are conducted with Porto Rican coffee and shade and to the west with imported varieties of coffee and shade trees.

Seed and nursery beds have been constructed, in which seeds from different sources have been planted. Among these were seven kinds of coffee imported from Brazil, which, however, owing to having been sent in bulk, and, in general, in a very bad and poor condition, did not come up at all. Several kinds from the Hawaiian Islands and Ceylon came up with fine results and have been already planted in the field. Coffee seed from Porto Rico, well prepared, all came up with exceedingly good results. To continue experiments with imported coffee it is desirable to secure as rapidly as possible seeds of a large variety of foreign material, and I would recommend giving the procuring of this material special attention.

Experiments with different plant distances have been begun by planting coffee at distances of 12 by 12, 10 by 10, 8 by 8, 6 by 6, and

4 by 4 feet, and the shade trees, which are representative of Porto Rico, have been planted between them.

COFFEE LEAF MINER.

So much damage is caused by this insect that experiments in exterminating it by collecting and destroying all infested leaves have been tried on several occasions. The first attempt was made at Mammeys on a patch of old coffee, in which nearly all the leaves were infested. After picking there were so few leaves left that the following crop was very much reduced. The succeeding one, however, was very much better.

The new nursery beds are situated in the virgin forest, a part of which has recently been felled and burned. There is no coffee growing nearer than 1,000 feet of these beds, and they are further sheltered by strips of standing forest which act as wind-breaks. Notwithstanding this isolation, these beds suffered in the beginning of May from an extremely heavy attack of leaf miner. As a remedy all the leaves attacked were continuously cut off and burned. The growth of the plants was retarded considerably, but they recuperated and are now in very fine and healthy condition, without any sign of the leaf miner.

At the station headquarters in Mayaguez the effect of picking the leaves is being tried on an isolated patch of about one acre. The pickings are being made at intervals of about two weeks, and a complete record is kept of the time required and the number of leaves collected at each picking.

The indications are that this method of extermination would prove such a stupendous task that it would be out of the question.

REPORT ON OBSERVATIONS IN PORTO RICO.

By Prof. F. S. Earle, *of the New York Botanical Garden.*

In accordance with the instructions of the Director of the Office of Experiment Stations, I visited Porto Rico for the purpose of studying its horticultural possibilities and of making observation on plant diseases. Owing to the short time at my disposal, it was impossible to make any extended investigations. The following notes are the result of a brief and hurried inspection of a small portion of the island, and are to be considered as suggestions indicating some lines along which work is needed, rather than as giving results of permanent value.

The horticultural crops now attracting most attention in Porto Rico are oranges and pineapples. Bananas are grown extensively, but mostly in the interior, where difficulties of transportation would prevent their becoming an article of export. Some of the lowlands near the coast are well adapted to the culture of bananas, and there seems no reason

why they could not be grown there profitably for the United States market. At present the subject seems to be receiving no attention. To successfully develop this, or in fact any other branch of the fruit business, better transportation facilities will be necessary. The present steamer service is poorly adapted for the transportation of perishable fruits.

Pineapples thrive in many parts of the island. The finest ones seen were in the neighborhood of Lajas, southeast of Mayaguez. A number of acres are grown here for the Mayaguez and Ponce markets. Some have been shipped to the States, but usually with unsatisfactory results, and the impression prevails that Porto Rican pines do not ship well. This is not remarkable when we remember that they are hauled in bulk often 15 miles in ox carts over a very rough road before being packed for shipment. Under these conditions it would be indeed astonishing if any arrive in good condition. The completion of the railroad now building between Mayaguez and Yauco will make it possible to deliver these at the seaboard in good condition, when their shipping qualities can be fairly tested. There is now a considerable commercial planting of pines in the neighborhood of San Juan. Some shipments from this region are reported as proving satisfactory and as carrying well. I see no reason why the growing of pines should not become a large and profitable industry. A small canning factory has been established at Mayaguez, which, if successful, will lead to a largely increased home market. Pineapples seem very healthy in Porto Rico. No diseases or serious insect pests were observed.

Many thousands of orange trees have been planted during the past two years, and the indications are that these plantings will be largely increased in the near future. The prospects for developing a successfull orange industry seem very flattering. There is an abundance of suitable land at reasonable prices. The quality of the fruit is good. Cheap labor, cheap freight rates, and the absence of tariff charges will make it possible to place Porto Rican oranges on the American market in competition with those grown in other countries. The climate is favorable, and so far no diseases or insect pests have been observed that are not to be encountered elsewhere with equal severity. Numerous kinds of scale insects occur, any one of which would be capable of doing great harm, but, as will be shown later, each seems to be held in check by one or more natural enemies. The business is still in its infancy, none of the recently planted groves having reached bearing age, and unforeseen troubles may, of course, develop; but the occurrence of old, healthy, and productive sweet seedling trees in all parts of the island argues well for the future success of the industry. Many other tropical fruits occur in Porto Rico. With the development of transportation facilities, especially when refrigerator transportation can be

secured, some of these may become profitable articles of export. There are, however, many difficulties, aside from those of transportation, in making a profitable market for new and untried fruits, and attempts in this direction should be made cautiously and, at first, on only an experimental scale. A few thrifty grapevines were observed in the neighborhood of Ponce. Judging from observations made in Jamaica, it is probable that some of the European or California varieties (*Vitis vinifera*) will thrive well on the southern or dry side of the island, and that they will ripen their crops well in advance of California, probably during May and June. If this proves to be a fact their cultivation would be profitable, provided adequate transportation facilities could be secured, since the American market is bare of grapes at this season.

NOTES ON DISEASES AND INSECTS.

ORANGES.

Orange scab (*Cladosporium* sp.).[a]—This is the only fungus disease of the orange that was observed. It causes wart-like swellings and distortions on the leaves and fruit. It does not often attack sweet oranges, but is usually confined to the sour oranges and the lemon. At present in Porto Rico it is doing no serious damage except to sour-orange seedlings in the nursery. A little more care in locating seed beds and nurseries at some distance from infected sour trees will prevent injury from this disease. It is unwise to plant nursery stock between the rows of orchard trees on account of the danger of the spreading of diseases and scale insects. Spraying with Bordeaux mixture or the ammoniacal solution of copper carbonate will protect trees from injury by scab. Spraying oranges with fungicides should only be resorted to as a last resort, as such sprays will kill the fungus enemies of the scale insects that are mentioned below.

Scale insects.—Four different scale insects were observed on the orange, any one of which would do great damage if allowed to multiply unchecked. Fortunately, a hymenopterous parasite and several fungus parasites are doing much toward destroying them. Judging from the thrifty condition of most of the old seedling trees, it seems reasonable to hope that these natural enemies will in the long run be able to prevent serious damage. The fact remains, however, that many individual trees are now suffering seriously from scale, and planters should provide themselves with the necessary apparatus for spraying these infested trees. It is doubtful if general spraying is either necessary or advisable, since it would tend to destroy the friendly

[a] Swingle and Webber, U. S. Dept. Agr., Division of Vegetable Physiology and Pathology Bul. 8, 1896, pp. 20–24.

parasites. In order of abundance, the orange scales observed were as follows:[a]

(1) *The purple scale* (*Mytilaspis citricola*).—This is probably the most abundant and widely occurring orange scale on the island. When numerous, especially on young trees, it does much harm. Fortunately, it is heavily parasitized by a minute hymenopterous insect and by at least three parasitic fungi. The hymenopter alone must be very effective in keeping down the numbers of the scale, since on many of the trees more than three-fourths of the mature scales were bored by the escaping parasite. Of the fungus parasite, one was the well-known red-scale fungus, *Sphærostilbe coccophila*. This occurs somewhat widely, but at the time of my visit, the close of the dry season, it was nowhere abundant. It probably spreads rapidly with the beginning of the rains, and is doubtless a factor of importance in keeping down this and other scales. This fungus can be easily cultivated in the laboratory,[b] and in moist weather the cultures mixed with water can be successfully used as a spray for introducing the fungus on trees where it does not occur naturally. Another widely occurring fungus forms a black coating over the scales. The individual black masses are small and rounded, 1 to 2 millimeters in diameter, but they are crowded together and often somewhat confluent over considerable areas when the scales are abundant enough to form an incrustation. At first these black masses are sessile, but at length some of them are more or less stalked and become quite hard. In most of the material secured no spores are present and the systematic position of the fungus remains in doubt. There can be no question of its parasitic nature, since at first it is confined exclusively to the scales and can be lifted away with them. The fungus seems to grow rather slowly, but when the scales are abundant it eventually destroys them over large areas. The trunks and limbs of many of the old trees on the island are blackened by the remains of this fungus. Some crude attempts at securing artificial cultures were made, but so far without success. What was probably this same black fungus was sent to the writer some years ago by Prof. W. M. Scott, State entomologist of Georgia, on San José scale from the southern part of that State.[c] There is a fragment of what seems to be the same fungus in the Ellis herbarium on orange twigs from Umatilla, Fla., collected by C. A. Hopkins, and sent to Mr. Ellis by Miss E. A. Southworth, then of the United States Department of Agriculture. The specimen is accompanied by notes and drawings by

[a] For the determination of these scales and much other assistance I am indebted to Prof. O. W. Barrett, entomologist of the Porto Rico Experiment Station.

[b] Rolfs, Florida Sta. Bul. 41, 1897, pp. 527–531.

[c] Professor Scott published an account of the good work done by this fungus in destroying the San José scale in Proc. Georgia State Hort. Soc., 22 (1898), pp. 69, 70.

Miss Southworth, and it was determined by Mr. Ellis as *Myriangium duriæi*, and is so reported by him,[a] but with the following note: "The measurements of asci and sporidia are from the Florida specimens; those from more northern localities have the sporidia mostly smaller. The Florida specimens also differ from those found in the northern States in the absence of any free margined, thalloid, effigurate subiculum."

In this specimen the fungus is situated on and among a mass of the same purple scale, though this is not noted by either Mr. Ellis or Miss Southworth. This is clearly a Myriangium, since the peculiar cellular stromatic masses have numerous ascigeral cavities, each containing a single suborbicular ascus, with muriform, hyaline spores. The asci and spores certainly closely resemble those of *M. curtisii*, which is usually regarded as a synonym of *M. duriæi*, and is a frequently occurring bark parasite on various trees and shrubs in the southern States; but besides the lack of a sterile effigurate subiculum, as noted by Mr. Ellis, the stromatic masses are flattened or slightly curved and not somewhat cup-shaped, as is usual in *M. curtisii*. One small piece of the Porto Rico material shows asci and spores that agree perfectly with this Florida specimen. The others noted above are sterile and of a harder consistency, although the young stages look exactly like the ascus-bearing specimen. The further study of more abundant material will be necessary for a full understanding of this interesting species.

The white fungus, described below under Lecanium, was occasionally found on the purple scale, but only when it had crept over from neighboring infected individuals of the Lecanium. It does not seem to be primarily a parasite of the purple scale.

(2) *The chaffy scale* (*Diaspis pentagona*).—This occurs very commonly on the orange, as well as on various other trees and plants. It is attacked to some extent by the black fungus mentioned above, but no other parasite was observed on it. On account of this lack of enemies it seems to be increasing more rapidly than either of the other orange scales and is, perhaps, more likely than any of the others to become seriously troublesome.

(3) *The "ant cow"* (*Lecanium hemisphæricum*).—This well-known greenhouse pest occurs on the orange in Porto Rico, usually attacking the young succulent twigs. It is heavily parasitized by a minute, white mold-like fungus[b] (*Sporotrichum* (?) sp.) that is first seen protruding from under the margin of the scale, but it soon completely envelopes and destroys it. The fungus produces immense numbers of exceedingly minute conidia that serve for its rapid propagation.

[a] North American Pyrenomycetes, 1892, p. 621.

[b] This fungus parasite occurs in Grenada and Barbados. See Scale Insects of the West Indies. H. Maxwell-Lefroy, West Indian Bul. 3, 1902, p. 314.

These are doubtless scattered to some extent by the wind, but it seems probable that they are more often inadvertently carried from the diseased to healthy scale by the small ants that always accompany this scale and can be seen running about among them in great numbers. With the beginning of the rainy season the fungus was multiplying with great rapidity and seemed abundantly able to hold the scale effectively in check. In fact on many trees it had already been completely exterminated.[a]

(4) *The red scale* (*Aspidiotus ficus*).—This scale was observed in several localities, but nowhere abundant enough to do much harm. It infests both the leaves and twigs. It is occasionally parasitized by the white fungus mentioned above, but not to the same extent as the Lecanium.

Other orange insects.—Two species of beetles belonging to the Curculionidæ were observed feeding on orange foliage. They are of about the same size (1 centimeter long), one being brown in color, the other light green. The green one was much the more abundant, and in some cases was seriously injuring the foliage. Whether, like the related Præpodes in Jamaica,[b] the larval stage fed upon the orange roots was not determined. It would doubtless be practicable to protect the trees from this injury by spraying with Paris green.

A large brown beetle (*Lachnosterna* sp.), closely resembling the May beetle, was abundant in the orange groves. Round holes, a centimeter or more in diameter, were often observed in the ground near the base of the trees. On digging down one or more pairs of these insects were always found. They did not seem to be feeding on the roots, and whether they were there for oviposition or only for shelter could not be determined. At night they emerge and fly about freely. The larva is probably a "white grub" feeding on plant roots, but whether particularly on orange roots is doubtful.

One species of small black ant occasionally does damage by gnawing the bark of young trees both below and above the surface of the ground. In some cases trees have been girdled and killed by them. The ants build little runways covered with particles of earth cemented together on the trunks of the trees where they are feeding, so that it is comparatively easy to find those trees that are being attacked. Some planters claim good results from brushing off these runways and applying a ring of coal tar to the base of the tree. As coal tar is often dangerous when applied to the bark of young trees, it was suggested to substitute a rosin mixture like a thin, sticky grafting wax, to be applied with a brush. This would cover and promote the healing of

[a] Since my return to New York I have found the same fungus on the scale in the greenhouse of the New York Botanical Garden.

[b] Jour. N. Y. Bot. Gard., 4 (1903), p. 8.

injured places and would probably prevent further attacks. These ants do not seem to live in large burrows or "ant hills," so it is difficult to destroy them with carbon bisulphid.

COFFEE.

Coffee has long been the leading agricultural crop of Porto Rico. A large part of the hill lands of the interior are probably better adapted to coffee than to any other commercial product. Owing to discouragement over the losses caused by the disastrous hurricane of 1899 and to the continued low prices, many of the estates are being greatly neglected and the production has fallen far below what it should be from so large an acreage. On only too many of the estates weeds and bushes are allowed to grow among the coffee unchecked, and the bananas, originally planted for shade, have multiplied through neglect until the coffee is being smothered. In many cases the trees were too closely planted in the first place and, with this overshading and no attempt at pruning or training, they have spindled up into slender, feeble bushes that are utterly unable to bear a satisfactory crop. Evidently, the greatest need of the coffee industry is for a reform in cultural methods. While coffee may require a certain amount of shade for its best development, it is certainly true that overshading and neglect are disastrous. Experiments to determine the proper amount of shade, the best kind of shade trees, the best distance for planting, and many other practical cultural questions are being undertaken by the Porto Rico Experiment Station at its substation on the Carmelita estate in the hills north of Ponce. Under the able supervision of Mr. Van Leenhoff, the coffee expert of the station, results of great practical value may be expected. While neglect in consequence of low prices is perhaps natural, it should be remembered that in any industry during periods of depression those producers are best able to survive who, by employing the best methods, are able to increase the total output without proportionally increasing the expense. Thus in the Southern States, during the years when 5 cents or less was the ruling price for cotton, those planters who by good management were able to produce a bale to the acre could still come out even, or perhaps make a small profit, while those who only produced a third of a bale per acre were plunged hopelessly into debt. It is the same with coffee. Those who neglect their estates during the present crisis will inevitably be forced out of the business, while for those who by industry and skill succeed in producing maximum crops there is still a reasonable profit even at present prices.

Coffee leaf miner (*Leucoptera coffeella*).—This insect seems to be the most serious coffee pest in Porto Rico. It is a minute silvery moth. The damage is done in the larval stage when it burrows within the

leaf tissues, causing the death of irregular areas 1 to 2 centimeters in diameter. When several of these dead areas occur on each leaf, as is often the case, the reduction of active leaf surface is so great as to seriously derange the nutrition of the plant. No natural enemies of this pest were observed. The larvæ are so protected, owing to their feeding on the inner tissues of the leaf, that applications of insecticides would be useless. The only possible remedy that suggests itself is the laborious one of hand picking and burning the infested leaves. At first thought this would seem impracticable with a crop like coffee on account of the expense. It is probable, however, that thorough work continued for a single season would so nearly exterminate the pest as to give practical immunity for a number of years. If so, the expense would be amply repaid by the increased yields of successive crops. The mature insect is so small that it is not likely that it flies far, and an estate once thoroughly cleaned up would be only slowly reinfested. This method of treatment is at least promising enough to deserve a practical test. A thorough study of the habits of the adult moth might suggest some means by which the insect could be more cheaply combated while in this stage, but in the absence of this knowledge no plan of attack can be suggested. The injury done by this insect is serious enough to demand a thorough investigation of its habits and life history.

Stilbum leaf spot (*Stilbum flavidum*).—In moister locations, and especially where overshaded, coffee leaves are also much spotted by this fungus. The Stilbum spots can easily be distinguished from those caused by the leaf miner by their lighter, nearly white color and regularly rounded outline. They are usually about 1 centimeter in diameter. The leaf miner spots are brown and irregular in outline. At certain times the fruiting bodies of the fungus can be seen with the naked eye abundantly scattered over the spots. They consist of minute, pale, yellow stalks, 2 to 3 millimeters high, ending in a small enlargement or knob. While the Stilbum disease is rather troublesome under present conditions it is not to be specially feared, since it only occurs where there is too much shade and moisture. It can be completely controlled by a proper thinning of the plantations and the cutting out of excessive shade.

Sclerotium (?) *leaf blight.*—A peculiar disease of coffee foliage was observed at one spot on the Carmelita estate. The above name is provisionally suggested for it, although no true Sclerotia were found. The underside of the leaves were covered by a thin weft of delicate white mycelium. On the petioles and twigs this mycelium was gathered into thick, tough brownish strands that advanced rapidly up the stems, spreading out again into a delicate white weft as each leaf was reached. No spore forms were observed, the fungus having the appearance of the mycelium of some of the hymenomycetes. The

infected leaves soon blackened and after a time dropped. No trees had been entirely killed by it, but all within the infected area (something less than an acre) were badly injured. It seems to be spreading rapidly in concentric circles, and it was strongly advised that all the infected trees be cut down and burned. The disease was not observed at any other point, and it is hoped that it is not widely distributed. If it should ever become prevalent it could doubtless be held in check by spraying with Bordeaux mixture, but for occasional sporadic outbreaks the cutting and burning of infected trees seems better and safer. The name given above was suggested by the close resemblance of this disease to one that occurs quite frequently on pear and other fruit trees in southern Georgia, Alabama, and northern Florida. During the season of midsummer rains this fungus spreads out over the twigs and foliage much as with this coffee fungus, but during the winter it assumes the form of brown sclerotium-like masses on the older twigs. The rainy season had begun when the coffee fungus was seen in Porto Rico. Whether it forms Sclerotia during the dry season or simply exists in the form of the thick brown strands noted above could not be determined.

Coffee root rot.—On one estate in the hills east of Mayaguez a serious root disease of coffee was observed. The roots are gradually killed by the growth of the delicate white mycelium of what is probably some hymenomycetous fungus. This spreads slowly underground from tree to tree. Unfortunately, the "guaba," one of the leguminous trees most widely planted as a coffee shade, is attacked by the same disease. In fact, it seems more susceptible than the coffee, since the diseased areas often seem to start from a dead or dying "guaba" tree as a center. Root diseases of this class are very difficult to combat. It may be necessary to entirely abandon the cultivation of coffee on badly infested areas. If so, it becomes a matter of prime importance to know what alternate crop could be safely planted on such infested lands. Where the disease is confined to certain small, well-defined areas it can be kept from spreading by digging and keeping open a deep trench around the infested areas, going deep enough to get well below the lateral spread of the roots. All trees within the area should be dug up and burned and no others planted for a period of years, since such fungi are usually very persistent, living on the dead roots, etc., in the soil. The disease was only observed in this one locality, but reports from various parties indicate that it is somewhat widely scattered.

Mealy bug at the root.—On examining the roots of certain feeble-looking trees they were found to be infested by some species of mealy bug. Lack of time prevented a sufficiently thorough investigation to determine whether such cases are abundant enough to cause material

damage. The trees in question had been stunted by overshading and neglect. It is doubtful if this trouble will prove a serious one where trees are in a condition of vigorous growth.

Leaf-eating insects.—A small gray beetle belonging to the Curculionidæ is doing much harm by gnawing the expanding terminal buds on the young twigs. As the leaf tissue gets older and harder it does not seem to be attacked. On some trees almost every bud had been gnawed and the young shoots very much injured. A few other unimportant leaf-eating insects were observed. Spraying with Paris green is the indicated remedy in those cases where the damage is sufficient to justify the expense.

Black aphis.—The young twigs of coffee are at times badly infested by a large black aphis (species not determined). At the time of my visit these were comparatively scarce and almost every individual seen showed evidence of being parasitized, probably by some hymenopterous insect.

Coffee scale (*Lecanium* sp.).—A large brown Lecanium (probably *L. hemisphæricum*) is also at times abundant and destructive, attacking the young growth and also the berries and peduncles. At the time of my visit but little of this scale could be found and that was heavily parasitized by the same white fungus (Sporotrichum?) mentioned above as attacking this scale on the orange. This fungus is so effective in destroying the Lecanium that it is to be hoped some way may be found for successfully cultivating it in the laboratory, so that it can be artificially introduced when natural infection fails to occur.

SUGAR CANE.

Next to coffee this is the most important commercial crop of the island. Owing to lack of time, it was impossible to make more than a casual investigation of this crop, and only one disease was noted. On the beautifully lying level coast lands, where cane is mostly cultivated, it would seem to be entirely practicable to use horse machinery in preparing and ditching the land and in cultivating the crop to a much greater extent than is now practical. The present excessive dependence on hand labor greatly increases the cost of production.

Sugar-cane root rot.—On entering Ponce by rail from Yauco considerable areas in certain fields were noted from the car windows where the young rattoon canes were very pale in color, in fact, almost milk white, and whose growth was very feeble. On visiting these fields the old stubble and the base of the young canes was found to be enveloped in a mass of the white mycelium of some hymenomycetous fungus. No fruit bodies of the fungus were found on the stubble or on living canes, but on some pieces of old cane lying on the ground well-developed specimens of a peculiar white Schizophyllum were found. The

disease resembles closely the Marasmius cane disease of Barbados,[a] and some of the other islands. It is possible that it will prove to be this disease, but the symptoms are slightly different, and no fruit bodies of the Marasmius could be found. *Schizophyllum lobatum* is known as a wound parasite in Java,[b] so it seems possible that the Schizophyllum found on the old canes may be connected with this root trouble, but no direct evidence of such a connection was secured. Laborers were at work digging out the dead and dying hills with hoes and replanting them. This will doubtless prove to be a waste of labor as the soil is so well stocked with the fungus that the new cuttings will soon contract the disease. Such areas should be at once plowed up and not replanted to cane for a term of years. So far as observed the disease was mostly confined to certain areas of poor, white, rocky soil, and it was only seen in this one locality. It is hoped that it will prove to be only a local outbreak. The soil on which it was found was poorly suited to cane in the first place and ought not to have been planted to this crop.

TOBACCO.

Tobacco is an important crop in Porto Rico. The quality of the leaf grown in the open is good, and recent experiments show that under cheese-cloth tents a wrapper leaf of the finest quality can be produced. It was offseason at the time of my visit, so that the only plants seen were those that had produced the regular crop and one rattoon or sucker crop that had been harvested and were now growing a second sucker crop that was being allowed to run up to seed. The indiscriminate saving of seed from such old and exhausted plants can hardly be a wise practice.

Tobacco wilt.—In one small field in a sandy river bottom near Ponce, a portion of these old plants were seen to be dying from some wilt disease. On pulling up the freshly wilted plants one or more of the fibrous roots were found to be brown and partially rotted, while the browning had extended up in irregular patches on the main root or crown until this had been girdled. In some cases this browning extended up to the surface of the soil. The disease seemed to involve the bark and cambium layer, but did not at first penetrate to the hard, central, woody tissues and did not discolor the vascular bundles. No fungus was observed on the freshly killed tissues. An agar tube inoculated on the spot with a fragment of the discolored tissue of the cambium layer has developed an abundant growth of bacteria, but no fungi. It has not been possible to make further studies of this disease. It should be carefully investigated, as it shows characteristics that might make it dangerous.

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[a] See A. Howard, Diseases of Sugar Cane in the West Indies, Annals of Botany, 17 (1903), pp. 391–413.

[b] Raciborski. See a review in Centbl. Bakt. u. Par., 2. Abt., 5 (1899), p. 169.

COTTON.

Cotton culture is beginning to attract some attention in Porto Rico. I saw no fields of cotton, but scattered plants of the perennial *Gossypium barbadense* were not uncommon along the roadsides. These thrive so well under conditions of absolute neglect that there can be no doubt as to the success of this crop when properly cultivated. Two leaf diseases were noted.

The true cotton rust.—The true cotton rust (*Uredo gossypii*) was collected on some of these wild plants near Mayaguez. It has heretofore only been reported from Ecuador. It causes small purplish-brown spots on the leaves and would probably cause them to fall prematurely. It is not, however, likely to prove particularly troublesome. It is entirely distinct from any of the diseases that have been called "cotton rust" in the United States.

Cotton areolate mildew.—This well-known disease of the Southern States, caused by *Ramularia areola*, also occurs on leaves of the wild cotton near Mayaguez. It produces white, frosted patches on the underside of the leaves. It is a disease of secondary importance, mostly occurring only on rank plants in moist places and doing but little harm.

COCOANUTS.

Cocoanuts are widely planted in Porto Rico. For the most part they seem quite healthy. No trace of either of the serious diseases found in Jamaica[a] was observed. In the neighborhood of Ponce many of the trees were yellow and some were dying. Inspection showed that the trouble was caused by scale insects. Fortunately, a lepidopterous larva was present in some numbers feeding on the scales. Specimens were secured by Professor Barrett, and it is to be hoped he will succeed in rearing them. Unless this or some other enemy of the scale multiplies very rapidly, a number of trees in the neighborhood of Ponce will be lost, as they are very badly infested.

CACAO.

This crop has so far attracted but little attention in Porto Rico. There are, however, some plantations and others are contemplated. Only a few opportunities for observing this crop were found, and but two diseases were noted. Some complaint was heard of losses of trees from root rot, but no cases were seen.

Cacao die back.—Certain trees that were growing in dry exposed places were gradually dying back from the tips of the branches. The appearance was something the same as where trees are suffering from

[a] See Report on a trip to Jamaica, Jour. New York Bot. Gard., 4 (1903), pp. 4–7.

some root trouble, but in these cases the roots were normal. The bark on the upper more exposed side of the twigs and branches was seen to be brown and diseased for some distance in advance of the death of the leaves. Some small pustules were observed on this diseased area containing rather immature pycnidia with large oval, continuous, colorless sporules. In this condition the fungus would be classed as a Macrophoma, but its appearance suggested that at full maturity the sporules would probably become brown, when they would be classed in Sphæropsis; or, if the spore became divided into two cells, in Diplodia. The sporules in the latter genus often remain for some time in this colorless condition before dividing and turning brown. A similar dying back of cacao limbs occurs in Grenada,[a] caused by *Diplodia cacaoicola*, P. Henn.[b] It seems probable that the Porto Rican fungus will prove to be this species, but unfortunately the material secured does not fully settle the question.

Cacao pod rot.—The same pod rot noted in Jamaica[c] occurs in Porto Rico. It usually attacks the blossom end first, finally involving the entire pod. The tissues turn brown and are somewhat softened, and the surface is soon covered by a white mold-like growth. This consists of delicate filament bearing great numbers of very minute oval spores. In agar cultures larger oblong septate spores are produced, showing that it is probably some species of Fusarium, though the spores are straight, not curved as is usual in this genus. Three rots of cacao pods have been described from the West Indies,[d] but this is clearly different from either of them. It promises to be quite destructive, especially during wet weather and where trees are overshaded.

PAPAW.

The papaw (*Carica papaya*) is a conspicuous tropical fruit and one that seems to have some commercial possibilities. The tree comes into bearing when less than a year old and produces enormous crops. The ripe fruits, which are about the size and shape of a muskmelon, have a very sweet, rich flesh that is liked by many people. With refrigeration they could doubtless be transported successfully to northern markets, where they would in time win a recognized place. The green fruits are boiled and used as a vegetable. Recently some interest has been attracted to this crop by its use for the manufacture of a

[a] The Fungoid Diseases of Cacao in the West Indies, Albert Howard, West Indian Bul. 2 (1901), pp. 203–205.

[b] For a further discussion of this fungus see *Diplodia cacaoicola*, P. Henn, a parasitic fungus of sugar cane and cacao in the West Indies, Albert Howard, Ann. of Bot., 15 (1901), pp. 683–701.

[c] Jour. New York Bot. Gard., 4 (1903), p. 9.

[d] See Mr. Howard's paper on Cacao Diseases, referred to above.

digestive agent that it is claimed is equal to or superior to animal pepsin. Unfortunately, the plant seems rather subject to diseases. Besides the two troubles mentioned below, it is attacked and injured by red spiders during the dry season, and Professor Barrett has observed a bud rot that kills the plant by destroying the terminal bud and the soft tissue at the apex of the stem. No cases of this disease were observed.

Papaw scale.—A scale insect, probably *Diaspis pentagona*, attacks the papaw very seriously and is killing a great many of the trees. No parasites were observed, and spraying will have to be resorted to to save the trees. So far as I know nothing is known as to the resistance of papaw foliage to kerosene or other insecticides, and experiments would have to be made to determine what treatment would be safest and most effective.

Papaw leaf blight.—A fungus (*Pucciniopsis caricæ*)[a] was observed in the neighborhood of San Juan. It forms small (1 millimeter) erumpent black masses on the under side of the leaves and causes more or less yellowing of the surrounding tissues. The attacked leaves fall prematurely. It seems more abundant on young seedlings, but was also observed on bearing trees. The damage done by it is usually of minor importance, but when combined with the attacks of the scale it hastens the death of the trees. Spraying with Bordeaux mixture is the indicated remedy.

BEANS AND COWPEAS.

Beans are extensively grown in Porto Rico and constitute an important element in the food supply. The common bean rust (Uromyces) was observed, and a few cases of two wilt diseases were found. Still a third wilt occurs on the cowpea. Neither of these wilts seemed to be caused by Neocosmospora, the common wilt fungus of the Southern States. They have not been sufficiently studied for further comment at this time. As they are probably of considerable economic importance, they should be fully investigated.

Doubtless many other diseases of economic plants occur that were not observed during the short time at my disposal. On the whole, the more important crops do not seem to be unusually subject to serious diseases. In fact, their production is less heavily handicapped in this way than in many competing countries; still enough is recorded above to indicate the need for a careful study of the diseases that do occur. The diseases of tropical plants have received comparatively little attention and the field is a wide and important one, since tropical products seem destined to play an ever-increasing part in the world's commerce.

[a] Bul. New York Bot. Gard., 2 (1902), p. 340. Described specimens sent from Sanibel Island, Florida, by S. M. Tracy.

In this connection attention should be called to the fact that so far Porto Rico has no legal protection against the introduction of injurious insects and diseases. The increased interest in the growth of horticultural products is certain to lead to the introduction of many new species and varieties of plants. It is by the introduction of infested plants that dangerous insects and diseases are usually disseminated. All of the more important horticultural States have found it necessary to protect their interests by providing for the inspection of nursery stock of all kinds. It would be wise for Porto Rico to follow their example and provide for the efficient inspection of all imported plants.